SCIENTIFIC AMERICAN SUPPLEMENT No. 853

Scientific American Supplement, Vol. XXXIII. No. 853.
Scientific American, established 1845.

NEW YORK, MAY 7, 1892.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

PHOTOGRAPHIC NOTES.

An interesting report is presented in a recent number of *The Engineer* (London), of the proceedings of the sixth annual conference of the Camera Club, which was recently held in the great hall of the Society of Arts, under the presidency of Captain W. de W. Abney, F.R.S., who in his opening address said that at the last International Photographic Congress, which met in Brussels, something had been done toward fixing international photographic standards in relation to lenses and apparatus. Last year M. Lippmann had shown how to give the colors of the spectrum upon a photographically developed image, that he could permanently fix them, and that they are the colors of thin plates. His own opinion was that the colors depended more upon the length of exposure than upon the light which fell upon the plates; he had also found that the colors reflected are not the pure colors of the spectrum, and do not agree with the colors found in nature. With Becquerel's experiments the same results were obtained, but in a more limited degree. During the past year Mr. H. M. Elder had brought forth a photo-mechanical theory to account for the decomposition of silver chloride, which theory had attracted the attention of some of our most eminent physicists. Mr. Vernon Boys had used shadow photography in experimenting on the flight of bullets, but did not pretend that he was the first to photograph bullets in their flight. Mr. Boys also had found that with copper terminals the most photographically active part of the electric light was confined nearly to the two terminals. In astronomical photography the astronomer royal had found that in photographing the stars, at all events, the intensity of the light and the length of the exposure seemed to him to be interchangeable. There seems to be a limit to the intensity of the light by which it is possible to decompose the salts of silver, and that limit is perhaps not much above the intensities with which photographers have to deal, which may account for some anomalies found by experience. There is a government school of photography at Chatham, but photographers want an institution open to all from which students may obtain certificates; it is desirable that some such institution should be started in a modest way, not aiming too high at first, and the Photographic Society is moving in the matter.

Mr. Leon Warnerke then read a paper on "Chemigraphic Etching," dealing with a process the principle of which was made known seventy years ago by a French savant, but not worked out by him. If some other metal be thinly precipitated upon a sheet of zinc, the plate is then attacked by an extremely weak acid solution, and the acid eats straight down; so that when this method is employed in photozinc etching, it is not necessary to apply a greasy or resinous coating now and then to the plate, to prevent the acid eating the metal away under the fine lines of the engraving. About the best salt to apply to the zinc was nickel ammonia tartrate, which gave a precipitate of nickel upon the parts of the plate unprotected; upon then, after washing, putting the plate in an extremely weak solution of sulphuric acid, the zinc was eaten away straight down; the acid should be weak enough not to attack pure zinc. He—the speaker—had also used chloride of iridium, and many other metallic salts; some acted better than others. It was not an indifferent matter what acid was employed; when nitric acid was used, the pure zinc alone was affected. Supposing the image to consist of gelatine upon a zinc plate, then the metallic salt employed should be dissolved in alcohol, since alcohol will not attack gelatine. He had tried sheets of aluminum for etching, since aluminum is tough, light, and costs but 7s. a pound, so bulk for bulk is of about the same price as copper. It is soluble in nitric, but not in several other strong acids; yet behaves like zinc after another metal has

Fig. 1.—MR. VAN DER WEYDE'S STUDIO AND ELECTRIC LIGHTING ARRANGEMENT.

Fig. 2.—A CONICAL PHOTOGRAPHIC STUDIO.

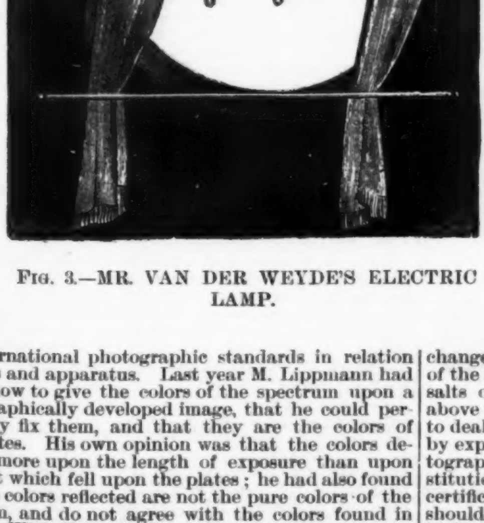


Fig. 3.—MR. VAN DER WEYDE'S ELECTRIC LAMP.

Fig. 4.—ONE OF MR. VAN DER WEYDE'S DEVELOPING ROOMS.

been thinly precipitated upon it, but it works rather capriciously. Mr. Warnerke then performed a curious experiment by putting drops of a solution of bichloride of mercury upon an aluminum plate, and after the lapse of about half a minute wiping off those drops; then he laid the plate upon the table. After the lapse of one or two minutes, fibers of alumina as white as snow began to rise in small forest-like groups upon the plate where the drops of solution had been. Sometimes they gradually rose, he said, to the height of 10 mm., and were beautiful objects when observed with a lens. Under the microscope, a minute globule of mercury is seen at the end of each fiber.

In the course of the discussion, Mr. Banks remarked that aluminum can now be bought in Liverpool at 4s. per pound.

Mr. H. M. Elder, M.A., stated that some time ago, at the Royal Institution, Mr. Roberts-Austen had shown the forest-like growth upon a plate of aluminum after rubbing its surface with metallic mercury. The action was longer in starting than in Mr. Warnerke's experiment, perhaps because of a thin film of something on the face of the metal, which film the acid salt used in Mr. Warnerke's experiment tended to remove. The etching method was a modification of the old copper zinc couple process of Gladstone and Tribe.

The chairman was doubtful whether, in etching very fine lines by the process, some biting-in under the lines would not take place, but Mr. Warnerke's experiments were always practical.

Mr. W. Willis read a paper upon "Recent Improvements in Platinotype Printing," and performed some experiments with a paper which gave platinotype prints at a lower temperature than with the hot bath process, and possessing points of advantage over the cold bath process.

The meeting was then adjourned until the evening.

At the reassembling of the conference on Tuesday evening, the first paper read was by Mr. Henry Van

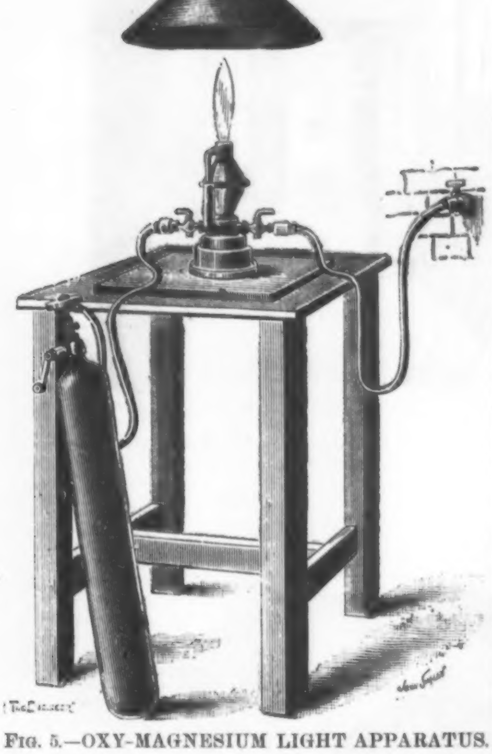


FIG. 5.—OXY-MAGNESIUM LIGHT APPARATUS.

der Weyde, "On Artificial Lighting in Photography." He had his electric lighting apparatus fitted up on the platform, and before the observers he took the likeness of Captain Abney, Sir George Prescott, and Mr. George Davison. He remarked that his arrangements were not so complete as at Regent Street, and invited the club to spend an evening at his studio. We have therefore pictured the permanent arrangement of the apparatus at his studio in the illustrations.

Fig. 1 represents Mr. Van der Weyde's portrait studio with the electric lighting arrangement. The light is obtained from one arc lamp of about 50 amperes, drawn from the mains. For about fifteen years he used a dynamo, driven by a gas engine, which arrangement he fitted up in 1877; this, he informs us, was the first large gas engine erected in London. It was one of Crossleys' and numbered 8. He did this, he states, in opposition to the advice of Messrs. Siemens, who informed him that it would be impossible to get the electric light suitably therewith. He found want of steadiness to be the principal fault, and he overcame it by putting on a fresh fly-wheel of additional weight.

In the cut a large hemispherical reflector will be observed suspended near the ceiling, and the whole apparatus is so arranged that not a single ray from the arc falls directly upon the sitter; a small saucer-shaped reflector at the lower end of the lamp prevents this by acting also as a screen. The whole arrangement is suspended by wire ropes and pulleys passing over an iron framework to a counterbalancing weight at the other end. This framework turns upon a pivot attached to the ceiling. By this arrangement the light can be pulled up or down, twisted right or left, or swung completely round the sitter; with the aid of plane reflectors in the studio, as represented in the engraving, any number of lighting effects may be obtained, and that without moving the sitter about. The concave reflector is made of zinc, covered with white enameled paper, for polished metal would give too much the same effect as of direct action from the luminous source. Round the edge of the large concave reflector is a zone which sends back into the reflector some of the light which otherwise would be sent in directions in which it is not required.

Fig. 2 represents Mr. Van der Weyde's daylight studio, which is remarkable for its conical form; it

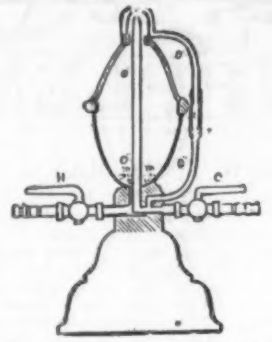


FIG. 6.—SECTION OF OXY-MAGNESIUM LAMP.

projects from the back of the main building. The "tunnel," or opaque part of the studio in which the camera is placed, is at the farther end of the cone, and the sitter is in the opening to the main building. The object of this conical form, and the way in which the studio is glazed, is that the light from the sky falling upon the sitter shall pass through the panes of glass at about a right angle. When they fall upon the glass obliquely in relation to the position of the sitter, more of the required rays are reflected from the two surfaces of the glass, so that they do not enter the studio or reach the sitter at all, and those rays which do pass traverse more glass.

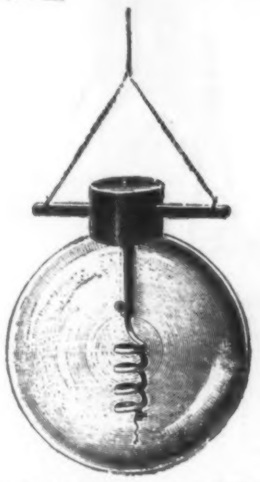


FIG. 7.—OXY-MAGNESIUM HAND LAMP.

Fig. 3 is a view of the interior of Mr. Van der Weyde's electric lamp and reflector already mentioned. The positive pole of the lamp faces the reflector, and is 20 mm. in diameter. The negative pole is but 15 mm. in diameter, in order to obstruct less of the light from the positive carbon.

Fig. 4 represents one of Mr. Van der Weyde's developing rooms. This one is in a vault underneath Regent Street. On the premises are twenty-three rooms devoted to various photographic purposes.

Mr. Van der Weyde, in his paper at the Camera Club conference, set forth that he endeavored in 1876 to condense some of the actinic light which the dull

FIGS. 8 AND 9.—SAFETY GAUGE ATTACHMENT FOR GASES.

gray sky of London affords during the greater part of the year, by constructing a plano-convex water lens, using two pieces of plate glass ¾ in. thick, one of which he convexed by heat to the depth of 8 in. The top of this lens, when in its iron frame, reached to the roof of his painting studio; the lens itself, within its iron ring, measured 6 ft. 6 in. in diameter, and was the largest in the world. When it was first being filled with filtered water—it held 987 lb.—he was standing under it, with his shirt sleeves rolled up, when there was a terrific explosion, a shower of glass and water, and he found himself on the floor, drenched to the skin, and his right fore-arm pierced through between the bones with the point of a large jagged splinter of glass, cutting the artery, and laying him up for six weeks. He soon saw that it was absolutely necessary to secure such a powerful and steady light that he could afford to do without direct rays altogether, and he constructed a Grove battery of 100 quarts, and secured a Fresnel dioptric lighthouse lens, 4 ft. in diameter, with a copper silvered reflector of the same size, and using a Serrin lamp, with a platinum screen of 4 in. to prevent a single ray from escaping. His first sitter was a relative. He was placed so close to the apparatus that his face turned fiery red, and streamed with perspiration. He was literally roasted. Mr. Van der Weyde closed his paper by saying: "I have studied, as every photographer must have done, the difference in the effects obtained from light which is reflected from a sunlit mass of clouds and from direct sunlight filtered through gauze or curtains, and I found that this relative difference between cloudlight and sunlight is exactly the same in regard to artificial light. There is a subtilty in the combined crispness and delicacy of the modeling obtained from purely reflected light which no arrangements of gauze or tissues filtering or diffusing direct light can possibly produce, and this proves that in attempting to produce artificial illumination, whether the same be for the painter or the photographer, one should not forget that there is only one kind of light that is worth imitating, and that is the broad and brilliant white, yet exquisitely soft reflected light, from a glorious mass of sunlit clouds in the northern sky."

Mr. E. J. Humphery, M.A., exhibited a new magnesium light of his invention. This lamp is shown in perspective in Fig. 5. The oxygen enters the lamp

FIG. 10.—A NEW SENSITOMETER.

from a cylinder, and common gas either at normal or, preferably, at a higher pressure. In the latter case a weighted gas bag is used. The powder is blown out in the shape of an Argand flame, but with pure oxygen in contact with its inner and outer surfaces. Above the flame is metal piping to convey the white smoke into the chimney of room. It gives a dazzling light, and Mr. Humphery stated that Captain Abney had testified that burning magnesium in an atmosphere of pure oxygen increases the actinic power of the light twelve times. A section of the lamp is given in Fig. 6. In this cut O^{11} is the oxygen tap, H the coal gas tap, and *m m* the magnesium powder. By burning thirty grains of magnesium powder in this lamp, a fully exposed platinotype print was obtained, as demonstrated to the conference by the reader of the paper.

Fig. 7 represents a glass globe in which magnesium ribbon is burnt in oxygen, and captures the smoke. This was exhibited at work by Mr. Humphery.

Professor Armstrong, F.R.S., then read a paper on "The Theory of Development."

Mr. J. B. Spurge then exhibited Messrs. Clarkson and Spurge's improved pressure gauge for compressed gas, devised in consequence of various accidents which have taken place with gauges. The instrument is represented in Fig. 8, the upper part of which is an ordinary Bourdon gauge with a specially formed inlet, by means of which the whole of the interior of the Bourdon tube is filled with glycerine, absolutely free from all traces of air. A is the plunger acted upon by the gas, and communicating pressure to the glycerine; should the Bourdon tube fracture, then the fluid will escape, and the plunger stop the orifice by acting as a valve. Fig. 9 is an apparatus for demonstrating that the energy required to indicate the pressure is $\frac{1}{16}$ of an ordinary gauge to give any particular indication due to the permanently charged tube. The coupling, A, is to connect it with a cylinder, V is valve which closes the outlet, B, and C is closed with a cap. The method of using this consists in attaching it to a cylinder, closing the valve, V, and opening the cylinder valve. The inclosed chamber will now be charged to the pressure of the cylinder, when it is again closed. The outlet controlled by V is

then put into communication with a small gas holder. V is next opened, and the gas measured by letting it expand into it. By substituting for the cap, C, the gauge and repeating the experiment, the difference in volume indicated by the holder will demonstrate the energy.

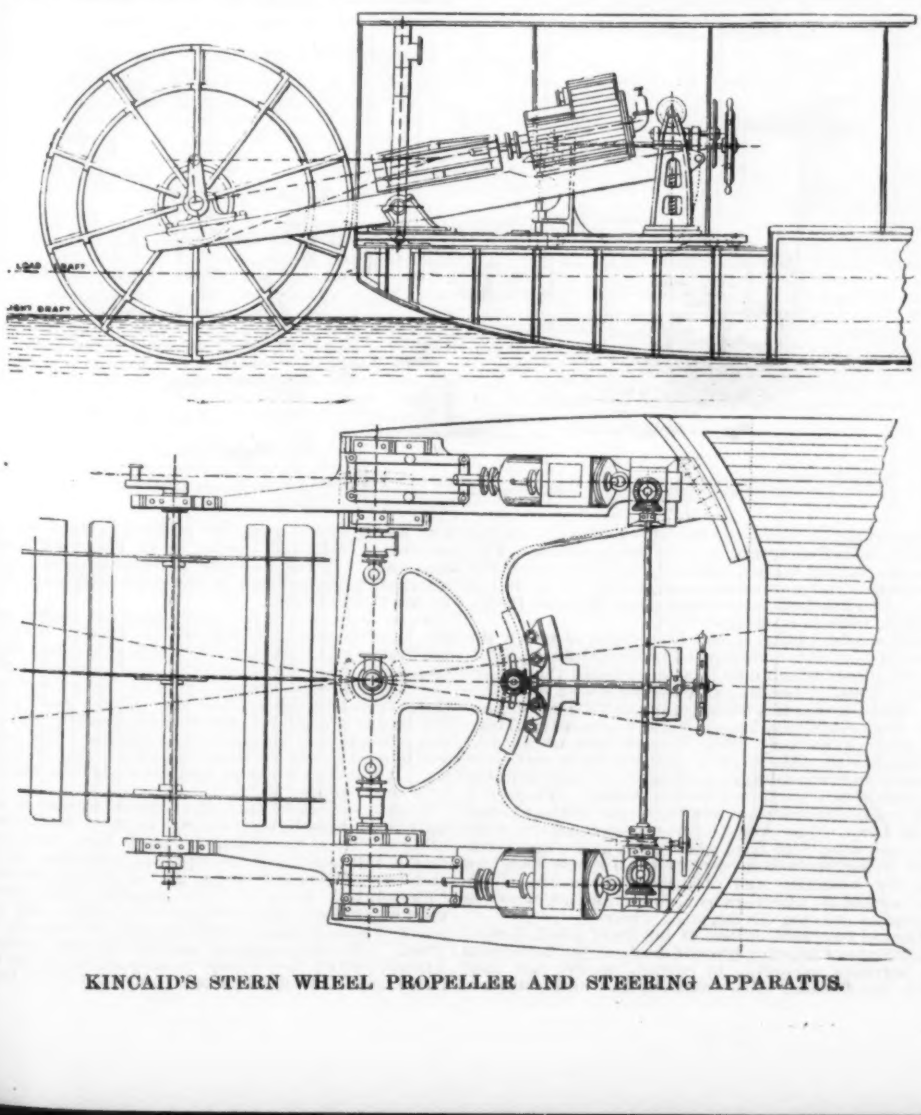
Mr. Spurge next exhibited his sensitometer, for testing the sensitiveness of photographic compounds; it consists of a rectangular box, one face of which is pierced with rows of holes, each adjacent pair of holes having areas varying in constant geometrical relationship. Behind each hole is a cubical chamber to which the hole acts as a window, and at the back of the chambers is the sensitive film or substance. Thus the area of each hole determines the amount of light falling on the film in a given time.

Fig. 10 is an instrument of precision, made by Mr. Spurge to determine certain controverted points among scientific photographers. It consists of a pendulum beating seconds, and giving a horizontal to-and-fro motion to a pencil which draws a line upon a drum, which line is sinuous when the drum is in motion; thus the time and rate of motion of the apparatus are graphically recorded throughout the whole of each experiment. The plate is placed at the back of a box, and light falls upon it through a row of square orifices; and as the plate is drawn upward by a pulley passing over the rotating drum with uniform velocity, a screen in front of the square orifices cuts off the light from one or other of them at regular intervals, as may be seen on reference to the cut. The two sensitometers described give identical results, and by them Mr. Spurge claims that he has proved that a feeble light acting for a long time will give the same gradation as a strong light acting for a short time, a point which has been a matter of dispute for a long time.

IMPROVED STERN WHEELER.

THERE is no doubt the superior efficiency of the stern wheel over the side wheel is partly due to the "following wave," as the floats of the stern wheel work, or should work, in the crest of this wave, the particles of which are actually in motion in the same direction as that in which the ship is going. Mr. Yarrow, whose name is so intimately connected with the development of this class of steamer, made an interesting experiment with reference to the "following wave" of these boats. He reefed the floats of a stern wheeler so that they did not touch the water, and naturally the vessel was unable to start from rest. He then had the vessel towed so that a "following wave" was induced, her engines were started, and it was now found that she could proceed alone, but, of course, directly they were stopped the wave subsided and she was unable to move. The fault the writer has found with the stern wheel steamers in his own experience is their bad steering qualities, which go far to neutralize the good ones mentioned above.

A combination to meet both difficulties is shown, and is the design of Mr. Kincaid, of Glasgow. The beams which carry the engines and paddle wheel are made to revolve in trunnions, and by means of screw gear the paddle wheel can be immersed to the most efficient draught according as the vessel is light or loaded. This arrangement has already been fitted to certain vessels in Africa, and has answered the expectations of the inventor. For steering purposes Mr. Kincaid proposes to revolve the whole bedplate containing the engines and paddle wheel in a horizontal direction, as shown above, so that the wheel can be moved through an angle of 15 degrees on each side of the center line of the vessel; in fact, to steer with the paddle wheel, and do away with the rudders altogether. The author believes that one of the reasons of bad steering in stern wheelers is that it has become the fashion to place the rudders ahead instead of abaft the paddle wheel. Thus placed, the rudders are in the most inefficient position, as on account of the bluff stern the water does not run in freely to them, and the paddle wheel is driving the water from instead of against them, and this explains (what the author has often noticed) the reason why a stern wheeler steers better when going astern than when going ahead, because the water is then driven against the rudders. There appears to be no very great difficulty in fixing a rudder both forward and abaft the paddle wheel, and this arrangement, the author thinks, would certainly give good results. The construction of this type of vessel also, as a rule, involves the use of the locomotive type of boiler, which, for reasons given later on, the author would, if possible, avoid for this service in India. Altogether the writer thinks that the most suitable class of steamer in every way (except when the allowable draught is less than 3 ft.) is the third type—*i. e.*, the side wheel paddle steamer, especially if fitted with compound disconnecting engines. Steamers of this type of comparatively large size can be built to draw not more than 3 ft. of water in working order, are very handy, and can be arranged to accommodate a large number of passengers. If, however, the draught is restricted to less than 3 ft., the stern wheeler appears most suitable.—*Industries.*

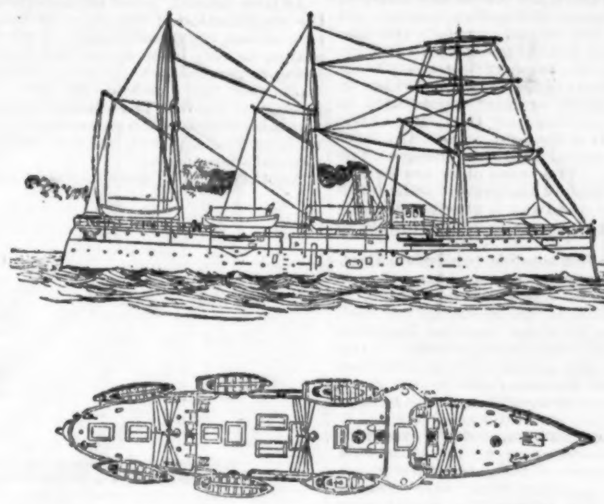


KINCAID'S STERN WHEEL PROPELLER AND STEERING APPARATUS.

OUR NEW PRACTICE CRUISER, THE GEORGE BANCROFT.

BUILT by Moore & Sons, Elizabeth, N. J., and named the George Bancroft, after the great historian, who was Secretary of the Navy at the time the United States Naval Academy was founded, and to whose interest and exertions, says the Boston *Herald*, the establishment of that valuable institution was largely due.

While intended primarily for the practical instruction of the naval cadets, both at the academy and during their annual summer cruises, the Bancroft is, nevertheless, fully equal to the performance of valuable service as a regular cruising war ship in case of hostilities, as will be seen from the description of her given below.



U. S. PRACTICE CRUISER GEORGE BANCROFT.

Her construction was authorized by act of Congress of September 7, 1888, and the contract for building her was awarded to the firm named above, and signed on July 18, 1890. By the terms of the contract her hull and machinery are to be completed not later than July 18, 1892, at a cost of $250,000.

The Bancroft is a steel, twin screw vessel, barkentine rigged, and of the following principal dimensions: Length on load water line, 187½ ft.; extreme breadth, 32 ft.; mean draught, 11½ ft.; displacement, 838 tons. Her engines are of the vertical triple expansion type, and will be capable of developing 1,300 indicated horse power and 13 knots speed. Her coal supply at normal draught is 140 tons, but her total bunker capacity is 200 tons. With the former supply she will be able to steam, without recoaling, 1,560 sea miles at 13 knots, and 2,400 sea miles at the ordinary cruising speed of 10 knots.

Her armament is quite good for a vessel of her size, and consists of four 4 in., three 3 pounder, two 3 pounder and one 1 pounder rapid fire guns, one 37 mm. Hotchkiss revolving cannon and one Gatling gun. She will also be fitted with two torpedo tubes, one being fixed in the bow, at the berth deck, and the other a dirigible tube on the upper deck. All her guns will have steel shields to protect them, but the vessel is otherwise unarmored.

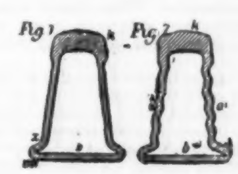
She will be lighted by electricity, furnished with steam windlass and steering gear, and provided with artificial ventilation. There will be quarters for eight officers besides the commanding officer, and accommodations for 130 naval cadets and enlisted men.

It is interesting to note that the Bancroft has but one contemporary in her class in the navies of the world. This is the Mexican practice cruiser Zaragoza, built in France and launched about a year ago. She is bark rigged, and, though larger than the Bancroft, is less effectively armed, her battery consisting of four 4·72 in. rifles (ordinary breech-loaders, not rapid firing, like those of the American ship), two 57 mm. rapid fire guns, and two 37 mm. revolving cannon. Her speed, though, is greater than that of the Bancroft, she having developed 15 knots on her trial trip last October. Her displacement is 1,200 tons, and she has accommodations for 230 men.

IMPROVED RAILWAY RAIL.

By R. MANNESMANN, Landore, South Wales.

THIS invention has reference to the construction of hollow rails. From the head *k* two slightly diverging side cheeks *a* descend to the base *b*. The sharply bent curves *x*, standing free, afford a certain amount of elasticity, and thereby materially weaken the transmission of the heavy shocks to which the top of the



rail is subjected. In order to prevent excessive noise due to vibrations on trains passing over them, and also to increase their weight, the hollow rails are filled with sand or glass granite, which becomes plastic at the temperature to which the rails are heated, and is thus incorporated with their internal surface by the rolling operation, whereby in addition to the prevention of noise their strength to resist transverse strain is increased. The adhesion of the filling to the metal surface is assisted by first applying a thin coating of enamels or oxides that readily liquefy at the heat which the rails attain, and that, having a greater tendency to adhere to the metal than the material constituting the filling, serve as an effectual cementing medium between the two, and cause the strains to be readily transmitted to the filling.

[FROM ENGINEERING.]

A SHORT HISTORY OF BRIDGE BUILDING.*

By C. R. MANNERS.

WE now come to the fourth and the last class, viz., beams or girders.

Beams may be of timber, stone, iron, or steel, and in any case the supporting material is partly in compression and partly in extension by the stress due to the load. Beams, or lintels, are, I suppose, the earliest method of bridging over a space. They are, in fact, prehistoric. We have in the stone corbel and lintel of the earliest Persian, Egyptian, and Indian temples, not only the beam or girder, but we have actually the cantilever and continuous girder of the great Forth Bridge, the construction of which has recently been completed.

What is believed to be the oldest existing bridge in Britain is a rude stone beam or lintel represented in Fig. 64. This bridge is over the East Dart, one of the streams on Dartmoor. It is thought to be fully 2,000 years old, and probably coeval with Stonehenge. The bridge is rude but strong. The three piers are formed of large granite blocks. Each of the granite slabs forming the superstructure or roadway is about 15 ft. long and 6 ft. wide, and must have given some trouble to place on the piers.

There are other similar but smaller bridges on Dartmoor, some of which are more perfect than this, in which unfortunately one of the piers has fallen. I believe the only place where anything similar has been found is in ancient Egypt, to which those on Dartmoor bear a strong resemblance. The earliest bridge of this class of which we have any record is that described by Herodotus, the Greek historian (484 to 408 B. C.) This was built by Nitrocris (a daughter of the King of Media), over the Euphrates, at Babylon, about 625 B. C. The piers were of stone and connected by movable planks, which were removed at night for protection, and so answered the purpose of the later drawbridge. The stones were fixed together with iron cramps, soldered in with lead. The bridge was roofed over. The course of the river is said to have been diverted to enable them to build the piers on a dry bed. No trace of this bridge has yet been discovered. The Greek historian Diodorus Siculus ascribes the work to Semiramis, which would throw the date back to 1100 or 1200 B. C. The frequent mention of bridges by Homer proves that they were not uncommon in Greece, or at least in the western part of Asia Minor, during his time, about 830 B. C.

The first bridge constructed at Rome of which there is any record was the Pons Sublicius, or wooden bridge (Fig. 65) built by Ancus Martius, fourth King of Rome (638 to 614 B. C.), when he united the Janiculum to the city. From the accounts of this bridge, the piers seem to have been formed of double rows of piles, twelve to each pier, united at the top in pairs by crossheads; on these again were bolted pieces of timber over each row of piles, and these again carried the longitudinal beams, which in their turn carried transverse pieces on which the flooring was laid. This bridge was probably a type of many of the early wooden bridges, and in fact is much the same as those of the present day.

It is said that neither iron nor nails were used in the construction of this bridge, but that wooden pins alone were employed, and that the whole could easily be taken to pieces. About 55 B. C., Julius Cæsar, in ten days, threw a bridge across the Rhine (Fig. 66). Cæsar tells us that two pieces of timber, 18 in. square, were pointed and sunk into the river at 2 ft. distant from each other, and driven in by machines. These piles were inclined a little and two others were driven at a distance of 40 ft. opposite them; these were also inclined, but in the opposite direction. Each pair were united by a transverse piece at the top 2 ft. thick and well secured. On these were laid joists in the direction of the breadth of the river; these were covered with hurdles to sustain the road. On the down-stream side inclined piles were driven to support the bridge against the force of the current, while on the up-stream side others were placed to protect the piers from floating trees, boats, etc.

It is probable that the Romans built many bridges of wood, as well as bridges with stone piers and wooden superstructures.

Of this latter kind the most important built in England were at Rochester, Newcastle, and London, remains of which have been found, and the solidity of which bears witness to the good work done by the Romans. In Scotland, at least one wooden bridge was built, on the line of the Roman road, and crossed the Tay at its confluence with the Almond.

The use of the drawbridge is believed to have been known to the Romans. The ancient form of this bridge was that of a strong flap of timber hinged at one end; the free end of this flap was raised by chains to an upright position, thus forming a barrier to a gateway, and at the same time leaving the moat or ditch impassable. In 1612 the remains of the camp of the sixth legion were discovered on the banks of the Irwell at Manchester. This camp appears to have been surrounded by a ditch or moat, which there is said to be good reason for supposing was crossed by a drawbridge.

While upon the subject of the drawbridge it may be convenient not only to dispose of it, but also of its successors, the swing and other movable bridges. Coming down then to more recent times, we still have the wooden drawbridge in use, but as a means of crossing navigable rivers or canals. These bridges were generally formed of two hinged flaps, one to be raised from each side of the opening by means of chains passed over high posts, or by piers of twice the length of the flap, balanced on their centers on posts, so that when one end was pulled down it raised the other, and the flap with it.

These old wooden structures, having served their purpose for the time being, have become things of the past and superseded by the Iron Age. The early iron draw or bascule bridge had counterpoise tail ends. The plain beam form became improved by forming the lower member of the girder into a portion of an arch which bore firmly on a skewback fixed to the masonry. Of such was the bridge built in 1839 carrying the Northeastern Railway over the Ouse at Selby. This bridge had two leaves or flaps, and gave a clear waterway of 45 ft.

* Continued from SUPPLEMENT, No. 851, p. 13595.

A great step was made in advance when the swing bridge was invented. I do not know to whom the honor of this invention is due, but Sir John Rennie mentions that one was first made in iron about the year 1810.

The earlier swing bridges, like their predecessors, the drawbridge, were made of timber trusses, in two leaves to cross single openings, and afterward they were made of heavy cast iron ribs or brackets. As Telford adopted cast iron swing bridges for crossing his canals, it is possible he may have been their inventor also, as they were introduced about his time.

As time passed, great improvements were made in the construction of this class of bridge, and they are now almost universally made of wrought iron or steel and up to very large spans, the lattice form of girder being in general use. In 1861 a bridge of this kind was built over the Penfield, at Brest, which has a clear passage of 350 ft. This class of bridge may turn upon a system of rollers, on a center pivot, on water center with hydraulic power, or by a combination of two or more of these means.

Another form of these movable bridges is the trav-

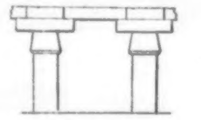


FIG. 63.

FIG. 64. DARTMOOR BRIDGE.

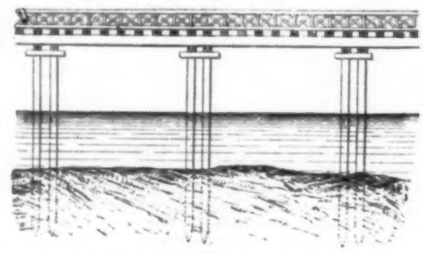


FIG. 65. THE PONS SUBLICIUS.

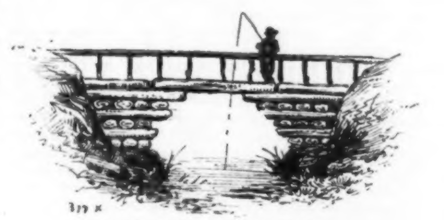


FIG. 67. NORWEGIAN BRIDGE.

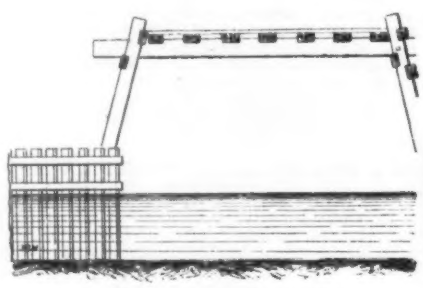


FIG. 66. CÆSAR'S BRIDGE.

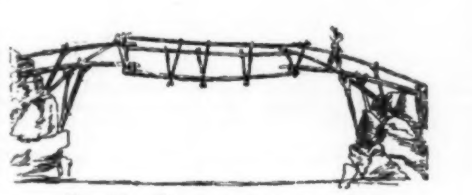


FIG. 68. NATIVE CANADIAN BRIDGE.

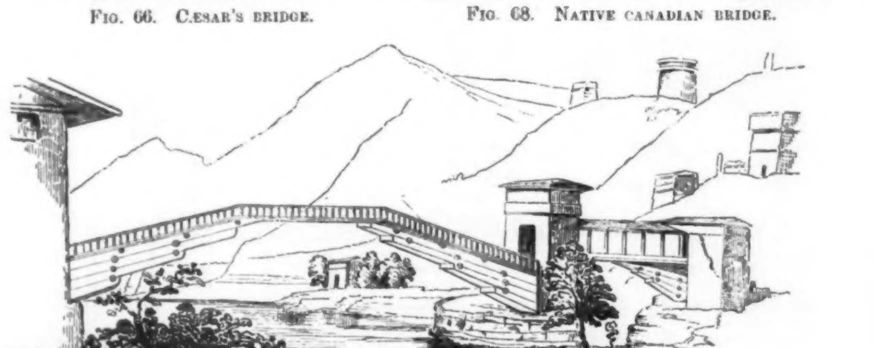


FIG. 69. WANDIPORE BRIDGE.

ersing bridge, in which the movable portion is capable of being rolled backward into the fixed portion. This is an old form of bridge, originally built of timber, but now modernized and sometimes constructed in steel or iron. One was built some years ago at Millwall Docks, London, with an opening of 80 ft.

Still another form is the lift bridge, in which the movable portion is bodily raised to the required height, an example of which may be seen crossing the Grand Surrey Canal at London, and having a span of 21 ft. 8 in. The erection of a bridge over the Thames at London must early have been a work of necessity, to take the place of the ferry. The Romans first established a trajectus on this river, to connect their station in London with the military road to Dover, and after the Romans it was continued by the Saxons. There is a rather singular tradition relating to one of the masters of the ferry. One, John Overy, rented the ferry of the city, and what with hard work, great gains, and penurious living, he became very rich. His only daughter was very beautiful and of a pious disposition. She was sought in marriage by a young gallant, who was ambitious of being the ferryman's heir.

The old ferryman, in one of his fits of greed, formed the scheme of feigning himself dead, in the hopes that his servants, according to custom, would fast until after the funeral. The servants, however, preferred feasting, broke into the larder and set to enjoy themselves. The poor dead man could not stand that long, but rose up in his sheet to rate them well. One of the men, thinking this was the devil, seized the butt end of a broken oar, and brained poor John Overy on the spot. Mary's gallant, hearing the news, rode off to town in all haste, but his horse stumbling he was thrown, and his neck broken. Poor Mary, the daughter, having lost both her father and her lover, founded the church which still bears her name, and made over her possessions to the college of priests which became thus established. These priests determined upon erecting a wooden bridge across the river, which was accordingly done in the reign of Ethelred II. (993-1016). William of Malmesbury states that in 994 Swerga, the Danish king, ran foul of the bridge when he sailed up the river to attack London, and that the bridge was destroyed in the fight which took place. It seems, however, to have been repaired, for when Canute sailed up the Thames with his fleet in 1016, he found the bridge in his way and cut a canal through the marsh on the south side, along which he drew his ships and completed the blockade of the city. In 1091 the bridge was again swept away by a flood, a new one was erected in 1097, and burned down about forty years afterward. It was, however, patched up and made to stand until the erection of the stone bridge in 1176, as we have already seen.

At an early period, probably about the beginning of the twelfth century, there was a wooden bridge at Rochester, and from ancient writings we find that it had nine stone piers placed at 43 ft. centers. Each bay or span was crossed by three beams, and upon these were laid thick planking. At the east end of this bridge a wooden tower was constructed and used as a gateway and for purposes of defense. This bridge was burned in 1264 by Simon Montfort, Earl of Leicester. It was soon restored, and has since been replaced by a stone bridge.

From a very early date the Chinese appear to have used large stone beams or lintels in the construction of bridges. Mendosa (Spanish classic, born 1503) states that in 1575 a party of two Spanish Augustine monks and two officers got access to China, and arrived at Chin-tcheou. He says: "The approach was across a most magnificent bridge 800 paces in length, and composed of stones, many of which were 22 ft. long by 5 ft. broad." He also mentions another similar bridge at Anchieo, which they found by measurement to be 1,300 paces long. Astley mentions that in 1662 the Dutch

deputies visited the town of Hok-swa, and passed the river Lo-yang by a bridge "remarkable for the immense masses of freestone with which it was paved, some being above 70 ft. long."

Heck, in his "Iconographic Encyclopædia," mentions a bridge at Lo-yang over an arm of the China Sea, 26,800 ft. or upward of five miles in length. This is probably the bridge referred to by Astley, who does not, however, mention its great length.

Heck also mentions one at Focheu, 22,000 ft. or upward of four miles long, and says both these bridges are 60 ft. to 70 ft. wide.

Miss Gordon-Cumming, in her "Wanderings in China," mentions a bridge at Foo-chou, which is called "Wan-show-keaou," "the bridge of ten thousand ages." This is possibly the second bridge mentioned by Heck. Miss Gordon-Cumming, however, gives the length as about one-third of a mile, and says the bridge has a solid roadway 14 ft. wide of enormous slabs of gray granite, some of which are 45 ft. long and 3 ft. square (about 30 tons weight), resting upon a series of 49 ponderous piers shaped like a wedge at each end. Miss Gordon-Cumming gives the age of this bridge as 900 years, but upon what authority is not stated.

At Kung-Kou are ruins of a still longer bridge, but of similar construction, and some distance up the river above Foo-chou is another with twenty-four massive stone piers. In 1876 a great flood swept right over the top of this bridge, and so great is its strength that the only damage done was the loss of a portion of the stone parapet.

Miss Gordon-Cumming also mentions a bridge about twenty miles up from Ning-po, supported on piers formed by clusters of separate upright stones. The roadway is roofed over with tiles, and there are shops at each end.

Mr. Potter, C.E., mentions that he is informed that at Osaka, the trading center of Japan, there were no less than 7,000 bridges over the rivers and canals with which the city is intersected. The typical Japanese bridge is timber of about 20 ft. spans, constructed of two piles connected by a distance piece; this supports longitudinal balks on which cross planking is laid; the roadway is of wicker work or bamboos covered with rods and earth.

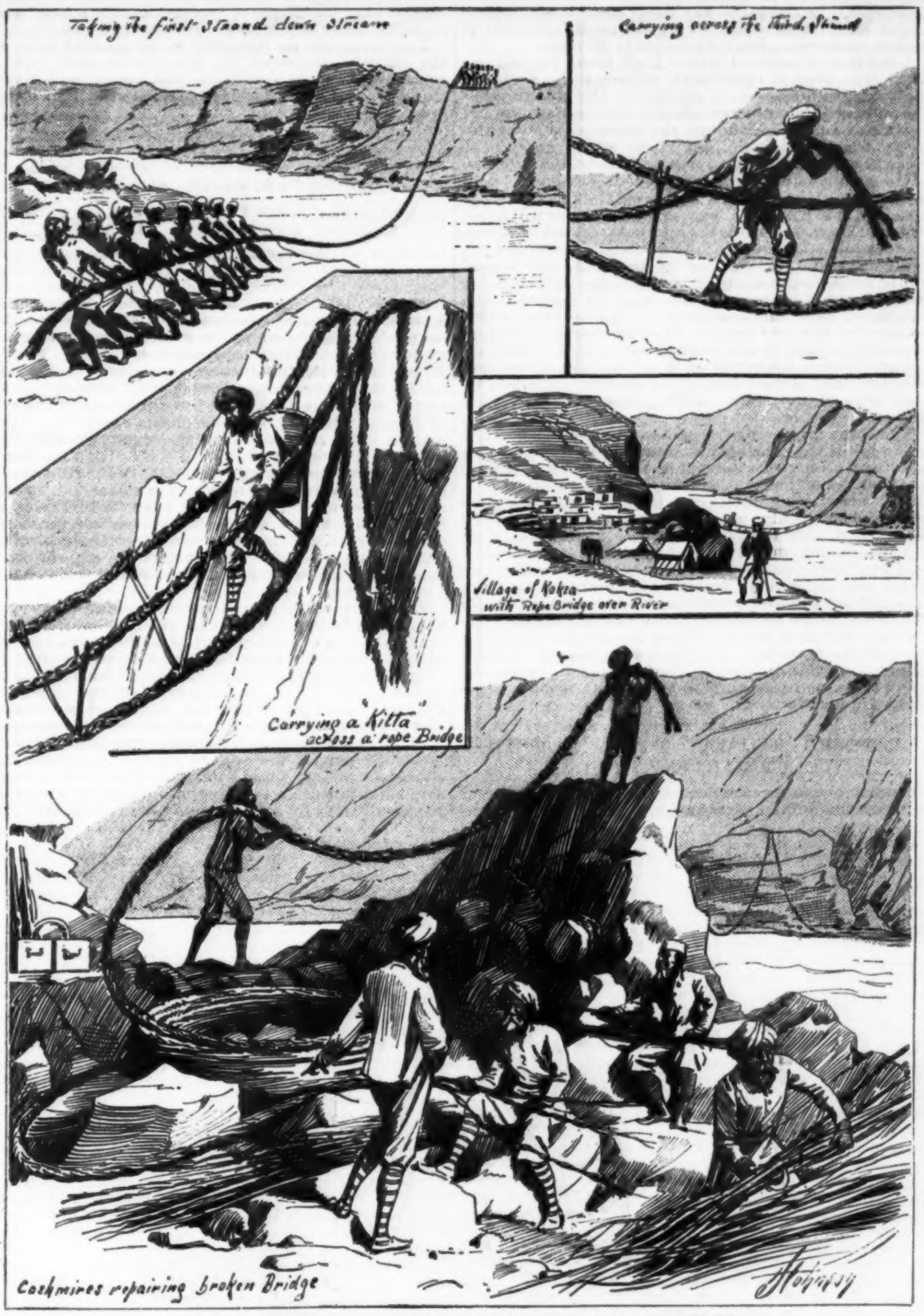
A very primitive timber bridge was in use in Norway (Fig. 67); the abutments being formed of logs of wood laid in layers crosswise and gradually corbeling out until the span was sufficiently reduced to be crossed by a single log.

Skeleton bridges of the cantilever and skeleton girder class have been used for ages by the savages, and a sketch (Fig. 68) is given of one found on the route of the Canadian Pacific Railway; this is a rather rough-and-ready forecast of the Forth Bridge.

Perhaps one of the most interesting structures of this kind is the bridge built about 230 years ago in Thibet (Fig. 69).

The sketch shown is from a drawing made in 1783 by Lieutenant Davis, R.N., who describes the bridge thus: "The bridge of Wandipore is of singular lightness and beauty in its appearance. The span measures 112 ft., it consists of three parts, two sides and a center, nearly equal to each other; the sides having a considerable slope raise the elevation of the center platform, which is horizontal, some feet above the floor of the galleries. A quadruple row of timbers, their ends being set in the masonry of the bank, and the piers support the sides. The center part is laid from side to side."

(To be continued.)

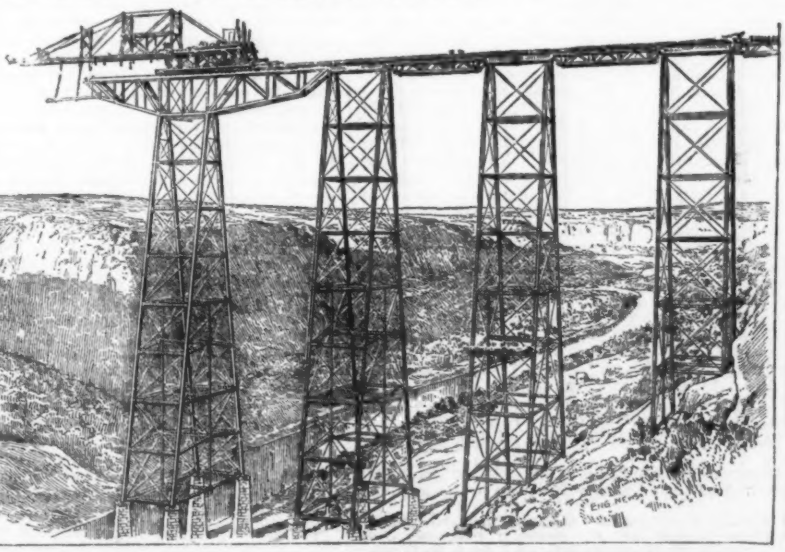


ROPE BRIDGE BUILDING IN CASHMERE.

THE PECOS RIVER BRIDGE.

THE large bridge over the Pecos River on the line of the Southern Pacific Ry. is rapidly approaching completion. The structure is located on the cut-off which the Southern Pacific Co. is building at a point on its line between Shumla and Helmet stations, in Texas, about 800 miles west of New Orleans, and by which it will shorten its line 12¼ miles besides avoiding the danger and expense of operating a line through the cañons of the Rio Grande. In addition to shortening the line, the new cut-off will materially reduce the grades and do away with a large amount of bridging and trestle work on the old line.

The only difficulty in carrying out this work was that of crossing the Pecos River, which at this point flows at the bottom of a cañon varying from 300 ft. to 400 ft. in depth, necessitating the construction of a bridge, or viaduct, of uncommon magnitude. This viaduct is 2,180 ft. long and 328 ft. above the surface of the stream; so that it comes next to the highest bridge in the world—the Loa Viaduct on the Antofagasta Railway in Bolivia, which is 336 ft. 6 in. high (*Eng. News*, May 18, 1889)—and is 26 ft. higher than the Great Kinzua Viaduct on the New York, Lake Erie & Western R.R. (*Eng. News*, July 5, 1890). The principal steel tower is 269 ft. 6 in. in height. The viaduct consists of 48 spans in all, most of which are iron plate girders, alternately 35 ft. and 65 ft. long. The channel span is a cantilever 185 ft. long. The floor system is 20 ft. wide and provides for a single line of railway track and two sidewalks for the use of employes. The bridge is built for carrying the heaviest freight trains; the short spans being designed to carry 2⅛ tons per lin. ft., and the long spans 2 tons per lin. ft. The substructure consists of masonry piers and, in the highest parts, steel trestle work towers.



THE PECOS RIVER BRIDGE, SOUTHERN PACIFIC RAILWAY.

The highest of these towers is 321 ft. and all are 35 × 100 ft. at the base and 10 × 35 ft. at the top. The stone used in the masonry is a hard compact limestone obtained from quarries in the vicinity of the work, with red granite from the Brenham, Tex., quarries for the coping and similar details.

The bridge was designed and built by the Phœnix Bridge Co., under the direction of Mr. Julius Krutschnitt, general manager of the Southern Pacific Co. The contractors for the masonry are Ricker, Lee & Co., of Galveston, Tex., who also have the contract for the grading on the cut-off. The erection of the iron work was begun on Nov. 1, 1891, and will be completed about March 1, 1892, over one-half of the work now being completed. We hope to give full details of this important work as soon after its completion as may be possible.—*Engineering News.*

ROPE BRIDGES IN CASHMERE.

A VERY interesting operation which I witnessed during a recent visit to Cashmere, says a correspondent of the *London Daily Graphic*, was the manufacture of a so-called "rope bridge." The part of the country north of Srinuggar is terribly rugged and precipitous. The rocky, snow-clad mountains descend abruptly to the foaming torrents running between them. The villages, occurring at rare intervals, are situated on small plateaus. The houses, which are without windows or chimneys, are entered through holes in the top. They are mostly formed of excavations, 5 ft. deep, surmounted by a low 3 ft. wall, roofed in with mud. The few cultivated fields are cut in steps from the mountain side. The only means the villagers possess of crossing the numerous wide and very swift streams are rope bridges, which are made of plaited birch or willow branches. They vary in length from a few feet up to a hundred yards, and, hanging high in a chasm, over a boiling torrent, they have a peculiar suggestion of fragility.

The branches used in their manufacture are about the size of one's finger, and 3 or 4 ft. long. These are trimmed of leaves and twigs to within 2 ft. of the top, where the shoots are allowed to remain. Strands 8 ft. long are then formed of these branches by roughly plaiting three of them together. As the branches come to an end fresh ones are inserted, care being taken not to put in more than one new branch at the

same spot. In the same way these strands are twisted round each other so as to form a continuous coil of basket-work rope about six inches in diameter.

A position is selected where high rocks jut out toward the river, in order that, although the weight of the bridge depresses it so greatly in the middle that the ends are almost perpendicular, the center may not touch the water; for though the material is comparatively tough, it would not stand strain enough to straighten it from bank to bank. The bridge is formed of three ropes stretching across the river—one to walk on, and another on each side, about the height of the hips, for the hands to rest on; the structure being stiffened by forked uprights and basket-work lashings at intervals of about 8 ft. The ropes are secured by being carried over the top of the rock, and wound round projecting corners of stone on the other side, or by being twisted round poles kept in position by a weight of loose earth and stones. In building a new bridge the first and second ropes have to be taken up to a narrow part of the stream, often some miles up the mountains, where the ends can be got across, and they are then carried down by a crowd of villagers on each side of the river, to the place chosen for the bridge.

The third rope is carried across on these when they are in position. The natives usually repair the bridges by substituting new ropes before the old ones give way, to avoid the difficulty of getting the ends across.

It is rather dizzy work going over till one gets used to it, as the bridge sways about a good deal as you tread on it, and in the center the rushing water, to fall into which would be certain death, is close below you, and keeps on catching your eye as you look down to see you are placing your feet correctly on the rope. It is difficult to avoid scratching one's hands, as one instinctively keeps them close to the rope in passing them forward, and they are caught by the jagged projecting butts of the branches. One of my coolies once slipped in going over with a load. Luckily he fell astride the lower rope, and was able to be rescued from a rather awkward position.

PROPOSED RAILWAY TOWER FOR THE COLUMBIAN EXPOSITION.

AMONG the numerous designs submitted for a tower for the Columbian Exposition is one as shown in the

TOWER PROPOSED FOR THE WORLD'S FAIR.

accompanying cut, taken from a sketch made by J. E. Harriman, Jr., a civil engineer of Boston.

Mr. Harriman has not only designed an observatory tower, but has combined with it the novel feature of a winding slide all the way from the top to the bottom.

This scheme would give passengers the opportunity of viewing the magnificent scenery and beautiful buildings of the fair from the different altitudes as they come down, each time describing larger circles and covering more space until they reached the bottom.

It will be seen that the proposed tower consists of four double main columns, coming together at the top, on which rests a building to be used as an observatory and for other purposes. Running from the center at the bottom perpendicularly to the top is a shaft to be used in carrying up the elevator cars and passengers.

It is proposed that each car shall have a guide or conductor, and be arranged to carry ten passengers. Starting from the bottom of the tower, the car would be carried up to the top, where the party alights and a party ready to descend taken in.

The car then leaves the elevator well, and enters upon the slide that is to carry it back to the starting point.

This slide descends on about a five per cent. grade; the car to be controlled by automatic brakes as well as by the conductor. The sides of the slide are protected by steel gratings, and it has a water and sun proof top.

When the car has almost reached the ground, the grade ascends again and brings the car to a standstill by the time it reaches the starting point.

The architect has not affixed any definite height to the tower, which could vary from that of Bunker Hill Monument to the height of the famous Eiffel Tower. If the tower was 500 feet high the slide would be about 1·9 miles long; if 1,000 feet high, the slide would be nearly four miles.

The cars would be kept a reasonable distance apart, and not travel faster than the electric street cars.

Other means for ascending and descending would be by regular elevators, which pass up and down the column as in the Eiffel Tower.

The room necessary for the proposed tower would be only the space taken up by the columns, as it could be erected over the largest of the buildings or a large arena could be made of the space between the columns.

The structure is designed to be made of steel, and the slide is supported by wire cables and rods. It would all be made in sections, and bolted and riveted together, and could be easily transferred by taking it apart.—*Boston Herald.*

[Continued from SUPPLEMENT, No. 852, page 13618.]

THE SQUARING OF THE CIRCLE.

AN HISTORICAL SKETCH OF THE PROBLEM FROM THE EARLIEST TIMES TO THE PRESENT DAY.*

By HERMANN SCHUBERT.

III.—HISTORICAL ATTEMPTS.

The Egyptian Quadrature.—In the oldest mathematical work that we possess we find a rule that tells us how to make a square which is equal in area to a given circle. This celebrated book, the Papyrus Rhind of the British Museum, translated and explained by Eisenlohr (Leipsic, 1887), was written, as it is stated in the work, in the thirty-third year of the reign of King Rā-a-us, by a scribe of that monarch, named Ahmes. The composition of the work falls accordingly into the period of the two Hiksos dynasties, that is, in the period between 2000 and 1700 B. C. But there is another important circumstance attached to this. Ahmes mentions in his introduction that he composed his work after the model of old treatises, written in the time of King Raenmat; whence it appears that the originals of the mathematical expositions of Ahmes are half a thousand years older yet than the Papyrus Rhind.

The rule given in this papyrus for obtaining a square equal to a circle specifies that the diameter of the circle shall be shortened one-ninth of its length and upon the shortened line thus obtained a square erected. Of course, the area of a square of this construction is only approximately equal to the area of the circle. An idea may be obtained of the degree of exactness of this original, primitive quadrature by our remarking that if the diameter of the circle in question is one meter in length, the square that is supposed to be equal to the circle is a little less than half a square decimeter larger; an approximation not so accurate as that computed by Archimedes, yet much more correct than many a one later employed. It is not known how Ahmes or his predecessors arrived at this approximate quadrature; but it is certain that it was handed down in Egypt from century to century, and in late Egyptian times it repeatedly appears.

The Biblical and Babylonian Quadratures.—Besides among the Egyptians we also find in pre-Grecian antiquity an attempt at circle computation among the Babylonians. This is not a quadrature; but aims at the rectification of the circumference. The Babylonian mathematicians had discovered that if the radius of a circle be successively inscribed as chord within its circumference, after the sixth inscription we arrive at the point of departure, and they concluded from this that the circumference of a circle must be a little larger than a line which is six times as long as the radius, that is, three times as long as the diameter. A trace of this Babylonian method of computation may even be found in the Bible; for in I. Kings vii., 23, and II. Chron. iv., 2, the great laver is described, which under the name of the "molten sea" constituted an ornament of the Temple of Solomon; and it is said of this vessel that it measured 10 cubits from brim to brim and 30 cubits roundabout. The number 3 as the ratio between the circumference and the diameter is still more plainly given in the Talmud, where we read that "that which measures three lengths in circumference is one length across."

Among the Greeks.—With regard to the earlier Greek mathematicians—as Thales and Pythagoras—we know that they acquired the foundations of their mathematical knowledge in Egypt. But nothing has been handed down to us which shows that they knew of the old Egyptian quadrature, or that they dealt with the problem at all. But tradition says that subsequently the teacher of Euripides and Pericles, the great philosopher and mathematician Anaxagoras, whom Plato so highly praised, "drew the quadrature of the circle" in prison, in the year 434. This is the account of Plutarch in the seventeenth chapter of his work "De Exilio."

Anaxagoras.—The method is not told us in which Anaxagoras had supposably solved the problem, and it is not said whether knowingly or unknowingly he accomplished an approximate solution after the manner of Ahmes. But at any rate, to Anaxagoras belongs the merit of having called attention to a problem that bore great fruit, in having incited Grecian scholars to busy themselves with geometry, and thus more and more to advance that science.

The Quadratrix of Hippias of Elis.—Again, it is reported that the mathematician Hippias of Elis invented a curved line that could be made to serve a double purpose; first, to trisect an angle and, second, to square the circle. This curved line is the *τετραγωνίζουσα* so often mentioned by the later Greek mathematicians, and by the Romans, called "quadratrix." Regarding the nature of this curve we have exact knowledge from Pappus. But it will be sufficient, here, to state that the *quadratrix* is not a circle nor a portion of a circle, so that its construction is not possible by means of the postulates enumerated in the preceding section. And therefore the solution of the quadrature of the circle founded on the construction of the *quadratrix* is not an elementary solution in the sense discussed in the last section. We can, it is true, conceive a mechanism that will draw this curve as well as compasses draw a circle; and with the assistance of a mechanism of this description the squaring of the circle is solvable with exactitude. But if it be allowed to employ in a solution an apparatus especially adapted thereto, every problem may be said to be solvable. Strictly taken, the invention of the curve of Hippias substitutes for one insuperable difficulty another equally insuperable. Some time afterward, about the year 350, the mathematician Dinostratus showed that the *quadratrix* could also be used to solve the problem of rectification, and from that time on this problem plays almost the same role in Grecian mathematics as the related problem of quadrature.

The Sophists' Solution.—As these problems gradually became known to the non-mathematicians of Greece, attempts at solution at once sprang up that are worthy of a place by the side of the solutions of modern amateur circle squarers. The Sophists, especially, believed themselves competent by seductive dialectic to take a stronghold that had defied the intellectual onslaughts of the greatest mathematicians. With verbal nicety, amounting to puerility, it was said that the squaring of the circle depended upon the finding of a number which represented in itself both a square and a circle; a square by being a square number, a circle in that it ended with the same number as the root number from which, by multiplication with itself, it was produced. The number 36, accordingly, was, as they thought, the one that embodied the solution of the famous problem.

Contrasted with this twisting of words the speculations of Bryson and Antiphon, both contemporaries of Socrates, though inexact, appear in high degree intelligent.

Antiphon's Attempt.—Antiphon divided the circle into four equal arcs, and by joining the points of division obtained a square; he then divided each arc again into two equal parts and thus obtained an inscribed octagon; thence he constructed an inscribed dodecagon, and perceived that the figure so inscribed more and more approached the shape of a circle. In this way, he said, one should proceed, until there was inscribed in the circle a polygon whose sides, by reason of their smallness, should coincide with the circle. Now this polygon could, by methods already taught by the Pythagoreans, be converted into a square of equal area; and upon the basis of this fact Antiphon regarded the squaring of the circle as solved.

Nothing can be said against this method except that, however far the bisection of the arcs is carried, the result must still remain an approximate one.

Bryson of Heraklea.—The attempt of Bryson of Heraklea was better still; for this scholar did not rest content with finding a square that was very little smaller than the circle, but obtained by means of circumscribed polygons another square that was very little larger than the circle. Only Bryson committed the error of believing that the area of the circle was the arithmetical mean between an inscribed and a circumscribed polygon of an equal number of sides. Notwithstanding this error, however, to Bryson belongs the merit, first, of having introduced into mathematics by his emphasis of the necessity of a square which was too large and one which was too small, the conception of maximum and minimum "limits" in approximations; and secondly, by his comparison with a circle of the inscribed and circumscribed regular polygons, the merit of having indicated to Archimedes the way by which an approximate value for π was to be reached.

Hippocrates of Chios.—Not long after Antiphon and Bryson, Hippocrates of Chios treated the problem, which had now become more and more famous, from a new point of view. Hippocrates was not satisfied with approximate equalities, and searched for curvilinearly bounded plane figures which should be mathematically equal to a rectilinearly bounded figure, and therefore could be converted by ruler and compasses into a square equal in area. First, Hippocrates found that the crescent-shaped plane figure produced by drawing two perpendicular radii in a circle and describing upon the line joining their extremities a semicircle, is exactly equal in area to the triangle that is formed by this line of junction and the two radii; and upon the basis of this fact the endeavors of the untiring scholar were directed toward converting a circle into a crescent. Naturally he was unable to attain this object, but by his efforts to this end he discovered many a new geometrical truth; among others the generalized form of the theorem mentioned, which bears to the present day the name of *Lunulæ Hippocratis*, the lunes of Hippocrates. Thus it appears, in the case of Hippocrates, in the plainest light, how the very insolvable problems of science are qualified to advance science; in that they incite investigators to devote themselves with persistence to its study, and thus to fathom its depths.

Euclid's Avoidance of the Problem.—Following Hippocrates in the historical line of the great Grecian geometricians comes the systematist Euclid, whose rigid formulation of geometrical principles has remained the standard presentation down to the present century. The elements of Euclid, however, contain nothing relating to the quadrature of the circle or to circle computation. Comparisons of surfaces which relate to the circle are indeed found in the book, but nowhere a computa-

* From Holtzendorff and Virchow's *Sammlung gemeinverstandlicher wissenschaftlicher Vortrage*, Heft 67. Hamburg: Verlagsanstalt, etc. Reprinted from *The Monist*, January, 1891, vol. 1, No. 2, pp. 197–228.—*Smithsonian Report*, 1890.

tion of the circumference of a circle or of the area of the circle. This palpable gap in Euclid's system was filled by Archimedes, the greatest mathematician of antiquity.

Archimedes' Calculations.—Archimedes was born in Syracuse in the year 287 B. C., and devoted his life, there spent, to the mathematical and the physical sciences, which he enriched with invaluable contributions. He lived in Syracuse till the taking of the town by Marcellus in 212 B. C., when he fell by the hand of a Roman soldier whom he had forbidden to destroy the figures he had drawn in the sand. To the greatest performances of Archimedes the successful computation of the number π unquestionably belongs. Like Bryson, he started with regular inscribed and circumscribed polygons. He showed how it was possible, beginning with the perimeter of an inscribed hexagon, which is equal to six radii, to obtain by way of calculation the perimeter of a regular dodecagon, and the perimeter of a figure having double the number of sides of the preceding one. Treating, then, the circumscribed polygons in a similar manner, and proceeding with both series of polygons up to a regular 96-sided polygon, he perceived on the one hand that the ratio of the perimeter of the inscribed 96-sided polygon to the diameter was greater than $6336:2017\frac{1}{4}$, and on the other hand that the corresponding ratio with respect to the circumscribed 96-sided polygon was smaller than $14688:4673\frac{1}{2}$. He inferred from this that the number π, the ratio of the circumference to the diameter, was greater than the fraction $\frac{6336}{2017\frac{1}{4}}$ and smaller than $\frac{14688}{4673\frac{1}{2}}$. Reducing the two limits thus found for the value of π, Archimedes then showed that the first fraction was greater than $3\frac{10}{71}$, and that the second fraction was smaller than $3\frac{1}{7}$, whence it followed with certainty that the value sought for π lay between $3\frac{1}{7}$ and $3\frac{10}{71}$. The larger of these two approximate values is the only one usually learned and employed. That which fills us most with astonishment in the Archimedean computation of π is first the great acumen and accuracy displayed in all the details of the computation, and then the unwearied perseverance that he must have exercised in calculating the limits of π without the advantages of the Arabian system of numerals and of the decimal notation. For it must be considered that at many stages of the computation what we call the extraction of roots was necessary, and that Archimedes could only by extremely tedious calculations obtain ratios that expressed approximately the roots of given numbers and fractions.

The Later Mathematicians of Greece.—With regard to the mathematicians of Greece that follow Archimedes, all refer to and employ the approximate value of $3\frac{1}{7}$ for π, without, however, contributing anything essentially new or additional to the problems of quadrature and of cyclometry. Thus Heron of Alexandria, the father of surveying, who flourished about the year 100 B. C., employs for purposes of practical measurement sometimes the value of $3\frac{1}{7}$ for π and sometimes even the rougher approximation $\pi = 3$. The astronomer Ptolemy, who lived in Alexandria about the year 150 A. D., and who was famous as being the author of the planetary system universally recognized as correct down to the time of Copernicus, was the only one who furnished a more exact value; this he designated, in the sexigesimal system of fractional notation which he employed, by 3, 8, 30—that is 3 and $\frac{8}{60}$ and $\frac{30}{3600}$, or as we now say 3 degrees 8 minutes (*partes minutæ primæ*) and 30 seconds (*partes minutæ secundæ*). As a matter of fact, the expression $3 + \frac{8}{60} + \frac{30}{3600} = 3\frac{17}{120}$ represents the number π more exactly than $3\frac{1}{7}$; but on the other hand is, by reason of the magnitude of the numbers 17 and 120 as compared with the numbers 1 and 7, more cumbersome.

Among the Romans.—In the mathematical sciences, more than in any other, the Romans stood upon the shoulders of the Greeks. Indeed, with respect to cyclometry, they not only did not add anything to the Grecian discoveries, but often evinced even that they either did not know of the beautiful result obtained by Archimedes or at least did not know how to appreciate it. For instance, Vitruvius, who lived during the time of Augustus, computed that a wheel 4 ft. in diameter must measure $12\frac{1}{2}$ ft. in circumference; in other words, he made π equal to $3\frac{1}{8}$. And, similarly, a treatise on surveying, preserved to us in the Gudian manuscript of the library at Wolfenbuttel, contains the following instructions to square the circle: Divide the circumference of a circle into four parts and make one part the side of a square; this square will be equal in area to the circle. Aside from the fact that the rectification of the arc of a circle is requisite to the construction of a square of this kind, the Roman quadrature, viewed as a calculation, is more inexact even than any other computation; for its result is that $\pi = 4$.

Among the Hindus.—The mathematical performances of the Hindus were not only greater than those of the Romans, but in certain directions even surpassed those of the Greeks. In the most ancient source for the mathematics of India that we know of, the Culvasutras, which date back to a little before our chronological era, we do not find, it is true, the squaring of the circle treated of, but the opposite problem is dealt with, which might fittingly be termed the circling of the square. The half of the side of a given square is prolonged one-third of the excess in length of half the diagonal over half the side, and the line thus obtained is taken as the radius of the circle equal in area to the square. The simplest way to obtain an idea of the exactness of this construction is to compute how great π would have to be if the construction were exactly correct. We find out in this way that the value of π, upon which the Indian circling of the square is based, is about from five to six hundredths smaller than the true value, whereas the approximate π of Archimedes, $3\frac{1}{7}$, is only from one to two thousandths too large, and the old Egyptian value exceeds the true value by from one to two hundredths. Cyclometry very probably made great advances among the Hindus in the first four or five centuries of our era; for Aryabhatta, who lived about the year 500 after Christ, states that the ratio of the circumference to the diameter is $62832 \div 20000$, an approximation that in exactness surpasses even that of Ptolemy. The Hindu result gives 3·1416 for π, while π really lies between 3·141592 and 3·141593. How the Hindus obtained this excellent approximate value is told by Ganeca, the commentator of Bhaskara, an author of the twelfth century. Ganeca says that the method of Archimedes was carried still farther by the Hindu mathematicians; that by continually doubling the number of sides they proceeded from the hexagon to polygon of 384 sides, and that by the comparison of the circumferences of the inscribed and circumscribed 384-sided polygons they found that π was equal to $3927 \div 1250$. It will be seen that the value given by Bhaskara is identical with the value of Aryabhatta. It is further worthy of remark that the earlier of these two Hindu mathematicians does not mention either the value $3\frac{1}{7}$ of Archimedes or the value $3\frac{17}{120}$ of Ptolemy, but that the latter knows of both values and especially recommends that of Archimedes as the most useful one for practical application. Strange to say, the good approximate value of Aryabhatta does not occur in Bramagupta, the great Hindu mathematician who flourished in the beginning of the seventh century; but we find the curious information in this author that the area of a circle is exactly equal to the square root of 10 when the radius is unity. The value of π as derivable from this formula (a value from two to three hundredths too large) has unquestionably arisen upon Hindu soil, for it occurs in no Grecian mathematician; and Arabian authors, who were in a better position than we to know Greek and Hindu mathematical literature, declare that the approximation which makes π equal to the square root of 10 is of Hindu origin. It is possible that the Hindu people, who were addicted more than any other to numeral mysticism, sought to find in this approximation some connection with the fact that man has ten fingers; and ten accordingly is the basis of their numeral system.

Reviewing the achievements of the Hindus generally with respect to the problem of the quadrature, we are brought to recognize that this people, whose talents lay more in the line of arithmetical computation than in the perception of spatial relations, accomplished as good as nothing on the pure geometrical side of the problem, but that the merit belongs to them of having carried the Archimedean method of computing π several stages farther, and of having obtained in this way a much more exact value for it; a circumstance that is explainable when we consider that the Hindus are the inventors of our present system of numeral notation, possessing which they easily outdid Archimedes, who employed the awkward Greek system.

Among the Chinese.—With regard to the Chinese, this people operated in ancient times with the Babylonian value for π, or 3, but possessed knowledge of the approximate value of Archimedes, at least since the end of the sixth century. Besides this, there appears in a number of Chinese mathematical treatises an approximate value peculiarly their own, in which $\pi = 3\frac{7}{50}$; a value, however, which, notwithstanding it is written in large figures, is no better than that of Archimedes. Attempts at the *constructive* quadrature of the circle are not found among the Chinese.

Among the Arabs.—Greater were the merits of the Arabians in the advancement and development of mathematics, and especially in virtue of the fact that they preserved from oblivion both Greek and Hindu mathematics, and handed them down to the Christian countries of the west. The Arabians expressly distinguished between the Archimedean approximate value and the two Hindu values, the square root of 10 and the ratio 62832:20000. This distinction occurs also in Muhammed Ibn Musa Alchwarizmi, the same scholar who in the beginning of the ninth century brought the principles of our present system of numerical notation from India and introduced the same into the Mohammedan world. The Arabians, however, studied not only the numerical quadrature of the circle, but also the constructive; as, for instance, Ibn Alhaitam, who lived in Egypt about the year 1000, and whose treatise upon the squaring of the circle is preserved in a Vatican codex, which has unfortunately not yet been edited.

In Christian Times.—Christian civilization, to which we are now about to pass, produced up to the second half of the fifteenth century extremely insignificant results in mathematics. Even with regard to our present problem we have but a single important work to mention—the work, namely, of Frankos Von Luttich upon the squaring of the circle, published in six books, but only preserved in fragments. The author, who lived in the first half of the eleventh century, was probably a pupil of Pope Sylvester II., himself a not inconsiderable mathematician for his time, and who also wrote the most celebrated book on geometry of the period.

Cardinal Nicolaus De Cusa.—Greater interest came to be bestowed upon mathematics in general, but especially on the problem of the quadrature of the circle, in the second half of the fifteenth century, when the sciences again began to revive. This interest was especially aroused by Cardinal Nicolaus De Cusa, a man highly esteemed on account of his astronomical and calendarial studies. He claimed to have discovered the quadrature of the circle by the employment solely of compasses and ruler, and thus attracted the attention of scholars to the now historic problem. People believed the famous cardinal and marveled at his wisdom, until Regiomontanus, in letters which he wrote in 1464 and 1465, and which were published in 1533, rigidly demonstrated that the cardinal's quadrature was incorrect. The construction of Cusa was as follows: The radius of a circle is prolonged a distance equal to the side of the inscribed square; the line thus obtained is taken as the diameter of a second circle, and in the latter an equilateral triangle is described; then the perimeter of the latter is equal to the circumference of the original circle. If this construction, which its inventor regarded as exact, be considered as a construction of approximation, it will be found to be more inexact even than the construction resulting from the value $\pi = 3\frac{1}{7}$. For by Cusa's method π would be from five to six thousandths smaller than it really is.

Bovillius, and Orontius Finæus.—In the beginning of the sixteenth century a certain Bovillius appears, who announced anew the construction of Cusa, meeting, however, with no notice. But about the middle of the sixteenth century a book was published which the scholars of the time at first received with interest. It bore the proud title "*De Rebus Mathematicis Hactenus Desideratis.*" Its author, Orontius Finæus, represented that he had overcome all the difficulties that had ever stood in the way of geometrical investigators; and incidentally he also communicated to the world the true "quadrature" of the circle. His fame was short lived. For afterward, in a book entitled "*De Erratis Orontii,*" the Portuguese Petrus Nonius demonstrated that Orontius' quadrature, like most of his other professed discoveries, was incorrect.

Simon Van Eyck.—In the period following this the number of circle squarers so increased that we shall have to limit ourselves to those whom mathematicians recognize. And particularly is Simon Van Eyck to be mentioned, who toward the close of the sixteenth century published a quadrature which was so approximate that the value of π derived from it was more exact than that of Archimedes; and to disprove it the mathematician Peter Metius was obliged to seek a still more accurate value than $3\frac{1}{7}$. The erroneous quadrature of Van Eyck was thus the occasion of Metius' discovery that the ratio 355 : 113, or $3\frac{16}{113}$, varied from the true value of π by less than one one-millionth, eclipsing accordingly all values hitherto obtained. Moreover it is demonstrable by the theory of continued fractions that, admitting figures to four places only, no two numbers more exactly represent the value of π than 355 and 113.

Joseph Scaliger.—In the same way the quadrature of the great philologist, Joseph Scaliger, led to refutations. Like most circle squarers who believe in their discovery, Scaliger also was little versed in the elements of geometry. He solved, however—at least in his own opinion he did—the famous problem; and published in 1592 a book upon it, which bore the pretentious title "*Nova Cyclometria,*" and in which the name of Archimedes was derided. The worthlessness of his supposed discovery was demonstrated to him by the greatest mathematicians of his time, namely, Vieta, Adrianus Romanus, and Clavius.

Longomontanus, John Porta, and Gregory of St. Vincent.—Of the erring circle-squarers that flourished before the middle of seventeenth century, three others deserve particular mention: Longomontanus, of Copenhagen, who rendered such great services to astronomy, the Neapolitan John Porta, and Gregory of St. Vincent. Longomontanus made $\pi = 3\frac{14185}{100000}$, and was so convinced of the correctness of his result that he thanked God fervently, in the preface to his work "*Inventio Quadraturæ Circuli,*" that he had granted him in his high old age the strength to conquer the celebrated difficulty. John Porta followed the initiative of Hippocrates, and believed he had solved the problem by the comparison of lunes. Gregory of St. Vincent published a quadrature the error of which was very hard to detect, but was finally discovered by Descartes.

Peter Metius and Vieta.—Of the famous mathematicians who dealt with our problem in the period between the close of the fifteenth century and the time of Newton, we first meet with Peter Metius, before mentioned, who succeeded in finding in the fraction 355:113 the best approximate value for π involving only small numbers. The problem received a different advancement at the hands of the famous mathematician Vieta. Vieta was the first to whom the idea occurred of representing π with mathematical exactness by an infinite series of continuable operations. By comparison of inscribed and circumscribed polygons, Vieta found that we approach nearer and nearer to π if we allow the operations of the extraction of the square root of $\frac{1}{2}$ and of addition and multiplication to succeed each other in a certain manner, and that π must come out exactly if this series of operations could be indefinitely continued. Vieta thus found that to a diameter of 10,000 millions units a circumference belongs of 31,415 million, and from 926,535 to 926,536 units of the same length.

Adrianus Romanus, Ludolf Van Ceulen.—But Vieta was outdone by the Netherlander Adrianus Romanus, who added five additional decimal places to the ten of Vieta. To accomplish this he computed with unspeakable labor the circumference of a regular circumscribed polygon of 1,073,741,824 sides. This number is the thirtieth power of 2. Yet great as the labor of Adrianus Romanus was, that of Ludolf Van Ceulen was still greater, for the latter calculator succeeded in carrying the Archimedean process of approximation for the value of π to 35 decimal places, that is, the deviation from the true value was smaller than one one-thousandth quintillionth, a degree of exactness that we can hardly have any conception of. Ludolf published the figures of the tremendous computation that led to this result. His calculation was carefully examined by the mathematician Griemberger, and declared to be correct. Ludolf was justly proud of his work, and following the example of Archimedes, requested in his will that the result of his most important mathematical performance, the computation of π to 35 decimal places, be engraved upon his tombstone, a request which is said to have been carried out. In honor of Ludolf, π is called to-day in Germany the Ludolfian number.

The New Method of Snell: Huygens's Verification of it.—Although through the labor of Ludolf a degree of exactness for cyclometrical operations was now obtained that was more than sufficient for any practical purpose that could ever arise, neither the problem of constructive rectification nor that of constructive quadrature was thereby in any respect theoretically advanced. The investigations conducted by the famous mathematicians and physicists Huygens and Snell, about the middle of the 17th century, were more important from a mathematical point of view than the work of Ludolf. In his book "Cyclometricus," Snell took the position that the method of comparison of polygons, which originated with Archimedes and was employed by Ludolf, need by no means be the best method of attaining the end sought: and he succeeded, by the employment of propositions which state that certain arcs of a circle are greater or smaller than certain straight lines connected with the circle, in obtaining methods that make it possible to reach results like the Ludolfian with much less labor of calculation. The beautiful theorems of Snell were proved a second time, and better proved, by the celebrated Dutch promoter of the science of optics, Huygens (*Opera Varia*, pp. 365 et seq.; *Theoremata De Circuli et Hyperbolae Quadratura*, 1651), as well as perfected in many ways. Snell and Huygens were fully aware that they had advanced only the problem of numerical quadrature, and not that of the constructive quadrature. This, in Huygens' case, plainly appeared from the vehement dispute he conducted with the English mathematician, James Gregory. This controversy has some significance for the history of our problem, from the fact

that Gregory made the first attempt to prove that the squaring of the circle with ruler and compasses must be impossible.

The Controversy between Huygens and Gregory.—The result of the controversy, to which we owe many valuable treatises, was that Huygens finally demonstrated in an incontrovertible manner the incorrectness of Gregory's proof of impossibility, adding that he also was of opinion that the solution of the problem with ruler and compasses was impossible, but nevertheless was not himself able to demonstrate this fact. And Newton, later, expressed himself to a similar effect. As a matter of fact, it took till the most recent period, that is over 200 years, until higher mathematics was far enough advanced to furnish a rigid demonstration of impossibility.

Before we proceed to consider the promotive influence which the invention of the differential and the integral calculus had upon our problem, we shall enumerate a few at least of that never-ending line of mistaken quadrators who have delighted the world by the fruits of their ingenuity from the time of Newton to the present period; and out of a pious and sincere consideration for the contemporary world, we shall entirely omit in this to speak of the circle squarers of our own time.

Hobbes's Quadrature.—First to be mentioned is the celebrated English philosopher Hobbes. In his book, "De Problematis Physicis," in which he chiefly proposes to explain the phenomena of gravity and of ocean tides, he also takes up the quadrature of the circle and gives a very trivial construction that in his opinion definitely solved the problem, making $\pi = 3\frac{1}{5}$. In view of Hobbes's importance as a philosopher, two mathematicians, Huygens and Wallis, thought it proper to refute Hobbes at length. But Hobbes defended his position in a special treatise, in which, to sustain at least the appearance of being right, he disputed the fundamental principles of geometry and the theorem of Pythagoras; so that mathematicians could pass on from him to the order of the day.

French Quadrators of the Eighteenth Century.—In the last century France especially was rich in circle squarers. We will mention: Oliver de Serres, who by means of a pair of scales determined that a circle weighed as much as the square upon the side of the equilateral triangle inscribed in it, that therefore they must have the same area, an experiment in which $\pi = 3$; Mathulon, who offered in legal form a reward of a thousand dollars to the person who would point out an error in his solution of the problem, and who was actually compelled by the courts to pay the money; Basselin, who believed that his quadrature must be right because it agreed with the approximate value of Archimedes, and who anathematized his ungrateful contemporaries, in the confidence that he would be recognized by posterity; Liger, who proved that a part is greater than the whole, and to whom therefore the quadrature of the circle was child's play; Clerget, who based his solution upon the principle that a circle is a polygon of a definite number of sides, and who calculated, also, among other things, how large the point is at which two circles touch.

Germany and Poland.—Germany and Poland also furnish their contingent to the army of circle squarers. Lieutenant Colonel Corsonich produced a quadrature in which π equaled $3\frac{1}{16}$, and promised 50 ducats to the person who could prove that it was incorrect. Hesse, of Berlin, wrote an arithmetic in 1776, in which a true quadrature was also "made known," π being exactly equal to $3\frac{1}{11}$. About the same time Professor Bischoff, of Stettin, defended a quadrature previously published by Captain Leistner, Preacher Merkel, and Schoolmaster Bohm, which made π *implicite* equal to the square of $\frac{1}{9}$, not even attaining the approximation of Archimedes.

Constructive Approximations: Euler, Kocahnsky.—From attempts of this character are to be clearly distinguished constructions of approximation in which the inventor is aware that he has not found a mathematically exact construction, but only an approximate one. The value of such a construction will depend upon two things—first, upon the degree of exactness with which it is numerically expressed, and secondly on the fact whether the construction can be more or less easily made with ruler and compasses. Constructions of this kind, simple in form and yet sufficiently exact for practical purposes, have for centuries been furnished us in great numbers. The great mathematician, Euler, who died in 1783, did not think it out of place to attempt an approximate construction of this kind. A very simple construction for the rectification of the circle, and one which has passed into many geometrical text books, is that published by Kochansky in 1685, in the *Leipziger Berichte*. It is as follows:

Erect upon the diameter of a circle at its extremities perpendiculars; with the center as vertex, mark off upon diameter an angle of 30°; find the point of intersection with the perpendicular of the line last drawn and join this point of intersection with that point upon the other perpendicular, which is at a distance of three radii from the base of the perpendicular. The line of junction thus obtained is then very approximately equal to one-half of the circumference of the given circle.

Calculation shows that the difference between the true length of the circumference and the line thus constructed is less than $\frac{1}{100000}$ of the diameter.

Inutility of Constructive Approximations.—Although such constructions of approximation are very interesting in themselves, they nevertheless play but a subordinate role in the history of the squaring of the circle; for on the one hand they can never furnish greater exactness for circle computation than the thirty-five decimal places which Ludolf found, and on the other hand they are not adapted to advance in any way the question whether the exact quadrature of the circle with ruler and compasses is possible.

The Researches of Newton, Leibnitz, Wallis, and Brouncker.—The numerical side of the problem, however, was considerably advanced by the new mathematical methods perfected by Newton and Leibnitz, commonly called the differential and the integral calculus. And about the middle of the seventeenth century, some time before Newton and Leibnitz represented π by series of powers, the English mathematicians Wallis and Lord Brouncker, Newton's predecessors in a certain sense, succeeded in representing π by an infinite series of figures combined by the first four rules of arithmetic. A new method of computation was thus opened. Wallis found that the fourth part of π is represented more exactly by the regularly formed product

$$\frac{2}{3}\times\frac{4}{3}\times\frac{4}{5}\times\frac{6}{5}\times\frac{6}{7}\times\frac{8}{7}\times\frac{8}{9}\times, \text{ etc.},$$

the father the multiplication is continued, and that the result always comes out too small if we stop at a proper fraction, but too large if we stop at an improper fraction. Lord Brouncker, on the other hand, represents the value in question by a continued fraction in which all the denominators are equal to 2 and the numerators are odd square numbers. Wallis, to whom Brouncker had communicated his elegant result without proof, demonstrated the same in his "Arithmetic of Infinites." The computation of π could hardly be farther advanced by these results than Ludolf and others had carried it, though of course in a more laborious way. However, the series of powers derived by the assistance of the differential calculus of Newton and Leibnitz furnished a means of computing π to hundreds of decimal places.

Other Calculations.—Gregory, Newton, and Leibnitz next found that the fourth part of π was equal exactly to

$$1-\tfrac{1}{3}+\tfrac{1}{5}-\tfrac{1}{7}+\tfrac{1}{9}-\tfrac{1}{11}+\tfrac{1}{13}-\ldots.$$

if we conceive this series, which is called the Leibnitzian, indefinitely continued. This series is indeed wonderfully simple, but is not adapted to the computation of π, for the reason that entirely too many members have to be taken into account to obtain π accurately to a few decimal places only. The original formula, however, from which this series is derived, gives other formulas which are excellently adapted to the actual computation. This formula is the general series:

$$\alpha = a-\tfrac{1}{3}a^3+\tfrac{1}{5}a^5-\tfrac{1}{7}a^7+\ldots$$

where α is the length of the arc that belongs to any central angle in a circle of radius 1, and where a is the tangent to this angle. From this we derive the following:

$$\frac{\pi}{4} = (a+b+c+\ldots)-\tfrac{1}{3}(a^3+b^3+c^3+\ldots)+\tfrac{1}{5}(a^5+b^5+c^5+\ldots)-\ldots$$

where $a, b, c\ldots$ are the tangents of angles whose sum is 45°. Determining, therefore, the values of $a, b, c\ldots$, which are equal to small and easy fractions and fulfill the condition just mentioned, we obtain series of powers which are adapted to the computation of π. The first to add by the aid of series of this description additional decimal places to the old 35 in the number π was the English arithmetician, Abraham Sharp, who, following Halley's instructions, in 1700, worked out π to 72 decimal places. A little later Machin, professor of astronomy in London, computed π to 100 decimal places; putting, in the series given above, $a = b = c = d = \frac{1}{5}$ and $e = -\frac{1}{239}$, that is employing the following series:

$$\frac{\pi}{4} = 4.\left[\frac{1}{5}-\frac{1}{3\cdot 5^3}+\frac{1}{5\cdot 5^5}-\frac{1}{7\cdot 5^7}+\ldots\right]-\left[\frac{1}{239}-\frac{1}{3\cdot 239^3}+\frac{1}{5\cdot 239^5}-\ldots\right]$$

In the year 1819, Lagny, of Paris, outdid the computation of Machin, determining in two different ways the first 127 decimal places of π. Vega then obtained as many as 140 places, and the Hamburg arithmetician, Zacharias Dase, went as far as 200 places. The latter did not use Machin's series in his calculation, but the series produced by putting in the general series above given $a = \frac{1}{2}$, $b = \frac{1}{5}$, $c = \frac{1}{8}$. Finally, at a recent date, π has been computed to 500 places.

The computation to so many decimal places may serve as an illustration of the excellence of the modern method as contrasted with those anciently employed, but otherwise it has neither a theoretical nor a practical value. That the computation of π to say 15 decimal places more than sufficiently satisfies the subtlest requirements of practice may be gathered from a concrete example of the degree of exactness thus obtainable.

Idea of Exactness Obtainable with the Approximate Values of π.—Imagine a circle to be described with Berlin as center, and the circumference to pass through Hamburg; then let the circumference of the circle be computed by multiplying its diameter with the value of π to 15 decimal places, and then conceive it to be actually measured. The deviation from the true length in so large a circle as this even could not be as great as the eighteen-millionth part of a millimeter.

An idea can hardly be obtained of the degree of exactness produced by 100 decimal places. But the following example may possibly give us some conception of it. Conceive a sphere constructed with the earth as center, and imagine its surface to pass through Sirius, which is $134\frac{1}{2}$ million million kilometers distant from us. Then imagine this enormous sphere to be so packed with microbes that in every cubic millimeter millions of millions of these diminutive animalcules are present. Now conceive these microbes to be all unpacked and so distributed singly along a straight line that every two microbes are as far distant from each other as Sirius from us, that is, $134\frac{1}{2}$ million million kilometers. Conceive the long line thus fixed by all the microbes as the diameter of a circle, and imagine the circumference of it to be calculated by multiplying its diameter with π to 100 decimal places. Then, in the case of a circle of this enormous magnitude even, the circumference thus calculated would not vary from the real circumference by a millionth of a millimeter.

This example will suffice to show that the calculation of π to 100 or 500 decimal places is wholly useless.

Prof. Wolff's Curious Method.—Before we close this chapter upon the evaluation of π, we must mention the method, less fruitful than curious, which Professor Wolff, of Zurich, employed some decades ago to compute the value of π to 3 places. The floor of a room is divided up into equal squares, so as to resemble a huge chess board, and a needle exactly equal in length to the side of each of these squares is cast haphazard upon the floor. If we calculate now the probabilities of the needle so falling as to lie wholly within one of the squares, that is so that it does not cross any of the parallel lines forming the squares, the result of the calculation for this probability will be found to be exactly equal to $\pi - 3$. Consequently a sufficient number of casts of the needle according to the law of large numbers must give the value of π approximately. As a matter of fact, Prof. Wolff, after ten thousand trials, obtained the value of π correctly to 3 decimal places.

IV.—PROOF THAT THE PROBLEM IS INSOLVABLE.

Mathematicians now seek to prove the insolvability of the problem. Fruitful as the calculus of Newton and Leibnitz was for the evaluation of π, the problem of converting a circle into a square having exactly the same area was in nowise advanced thereby. Wallis, Newton, Leibnitz, and their immediate followers distinctly recognized this. The quadrature of the circle could not be solved; but it also could not be proved that the problem was insolvable with ruler and compasses, although everybody was convinced of its insolvability. In mathematics, however, a conviction is only justified when supported by incontrovertible proof; and in the place of endeavors to solve the quadrature there accordingly now come endeavors to prove the impossibility of solving the celebrated problem.

Lambert's Contribution.—The first step in this direction, small as it was, was made by the French mathematician, Lambert, who proved in the year 1761 that π was neither a rational number nor even the square root of a rational number; that is, that neither π nor the square of π can be exactly represented by a fraction the denominator and numerator of which are whole numbers, however great the numbers be taken. Lambert's proof showed, indeed, that the rectification and the quadrature of the circle could not be possibly accomplished in the particular way in which its impossibility was demonstrated, but it still did not exclude the possibility of the problem being solvable in some other more complicated way, and without requiring further aids than ruler and compasses.

The Conditions of the Demonstration.—Proceeding slowly but surely, it was next sought to discover the essential distinguishing properties that separate problems solvable with ruler and compasses from problems the construction of which is elementarily impossible, that is, by solely employing the postulates. Slight reflection showed that a problem elementarily solvable must always possess the property of having the unknown lines in the figure relating to it connected with the known lines of the figure by an equation for the solution of which equations of the first and second degree alone are requisite, and which may be so disposed that the common measures of the known lines will appear only as integers. The conclusion was to be drawn from this that if the quadrature of the circle, and consequently its rectification, were elementarily solvable, the number π, which represents the ratio of the unknown circumference to the known diameter, must be the root of a certain equation, of a very high degree perhaps, but in which all the numbers that appear are whole numbers; that is, there would have to exist an equation, made up entirely of whole numbers, which would be correct if its unknown quantity were made equal to π.

Final Success of Professor Lindemann.—Since the beginning of this century, consequently, the efforts of a number of mathematicians have been bent upon proving that π generally is not algebraical, that is, that it cannot be the root of any equation having whole numbers for coefficients. But mathematics had to make tremendous strides forward before the means were at hand to accomplish this demonstration. After the French academician, Professor Hermite, had furnished important preparatory assistance in his treatise *Sur la Fonction Exponentielle*, published in the seventy-seventh volume of the *Comptes Rendus*, Prof. Lindemann, at that time of Freiburg, now of Konigsberg, finally succeeded, in June, 1882, in rigorously demonstrating that the number π is not algebraical,* thus supplying the first proof that the problems of the rectification and the squaring of the circle, with the help only of algebraical instruments like ruler and compasses, are insolvable. Lindemann's proof appeared successively in the reports of the Berlin Academy (June, 1882), in the *Comptes Rendus* of the French Academy (vol. cxv., pp. 72–74), and in the *Mathematischen Annalen* (vol. xx., pp. 213–225).

The Verdict of Mathematics.—"It is impossible with ruler and compasses to construct a square equal in area to a given circle." These are the words of the final determination of a controversy which is as old as the history of the human mind. But the race of circle squarers, unmindful of the verdict of mathematics, that most infallible of arbiters, will never die out so long as ignorance and the thirst for glory shall be united.

* For the benefit of my mathematical readers, I shall present here the most important steps of Lindemann's demonstration. M. Hermite, in order to prove the transcendental character of

$$e = 1+\frac{1}{1}+\frac{1}{1.2}+\frac{1}{1.2.3}+\frac{1}{1.2.3.4}+\ldots.$$

developed relations between certain definite integrals (*Comptes Rendus* of the Paris Academy, 1873, vol. lxxvii.) Proceeding from the relations thus established, Professor Lindemann first demonstrates the following proposition: If the coefficients of an equation of nth degree are all real or complex whole numbers and the n roots of this equation $z_1, z_2, \ldots, z_n$ are different from zero and from each other, it is impossible for

$$e^{z_1}+e^{z_2}+e^{z_3}\ldots.+e^{z_n}$$

to be equal to $\frac{a}{b}$, where a and b are real or complex whole numbers. It is then shown that also between the functions

$$e^{rz_1}+e^{rz_2}+e^{rz_3}+\ldots.e^{rz_n}$$

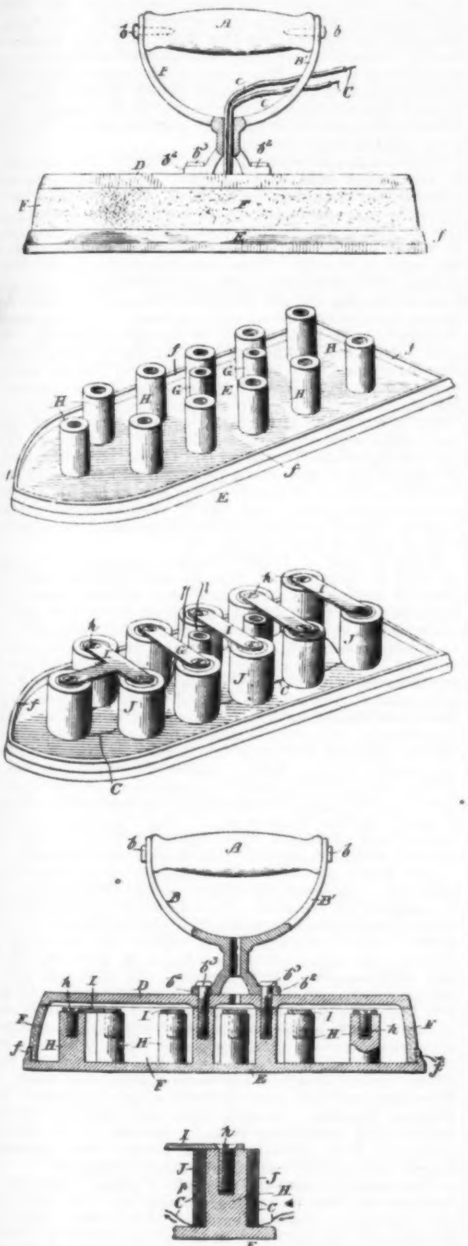
where r denotes an integer, no linear equation can exist with rational coefficients variant from zero. Finally the beautiful theorem results: If z is the root of an irreducible algebraic equation the coefficients of which are real or complex whole numbers, then e^z cannot be equal to a rational number. Now, in reality $e^{\pi\sqrt{-1}}$ is equal to a rational number, namely, —1. Consequently, $\pi\sqrt{-1}$, and therefore itself, cannot be the root of an equation of nth degree having whole numbers for coefficients, and therefore also not of such an equation having rational coefficients. If the squaring of the circle with ruler and compasses were possible, however, π would have the property last mentioned.

ELECTRIC SMOOTHING IRON.

MR. WILLIS MITCHELL, of Malden, Mass., has patented this device. A, the ordinary wooden grasping piece of the handle of a tailor's smoothing iron, the metallic frame of said handle consisting of two counterpart supporting bars B B', in the upper ends of which the said grasping piece is journaled by gudgeons b. To allow this journaling the said bars curve outward and upward divergently from near the middle. Below this they are vertical and parallel for a short distance, their inner faces being shaped to form a guide passage for insulating cords c c containing the two ends of the wire C, which enter the hollow tailor's iron through an opening in the middle of its top plate D, side by side.

The lower ends of bars B B' are provided with horizontal reversely extending feet b^2, which are fastened to the body of the iron by screws b^3 or in any other convenient manner.

The iron is hollow, and consists of a solid metallic body or bottom plate E, and the aforesaid top plate with interposed side walls F, of asbestos. These walls greatly lessen the weight of the implement without impairing its efficiency for ironing; but they are not absolutely necessary, as the sides of the body E may



ELECTRIC SMOOTHING IRON.

be extended up to the said top plate; but when the asbestos walls F are used, as shown, these sides are ex tended up only a little way, forming a peripheral rim f, which affords a base for the said asbestos walls. The metallic body thus constructed is, in effect, a bottom plate with a thick raised rim, and a number of posts or studs in the space which that rim incloses. These studs or posts are raised on the flat upper face of the said body or bottom plate, and are preferably cast therewith. Like said body, they are of magnetic metal. Two of these posts are centrally screw-tapped on top to receive the screws, b^3. The other posts are also screw-tapped to receive screws h, whereby bridges I are fastened to them. Each one of these cores or posts H is surrounded by a cylindrical heating device consisting of a part of the wire C, wound in successive concentric helices with interposed cylinders of asbestos J, the wire being preferably naked and wound at such intervals as I have found to give the greatest heat. The wire is wound first on the core upward, then downward on the first asbestos cylinder, then upward on the next, and thus end for end until a sufficient number of coils have been provided. The wire then passes to the next post or core H, and this is wound in like manner, the winding continuing post after post until each core is properly equipped for heating. The bridges, I, which may be of any suitable form or number or even united in a single plate, serve to keep the heating coils and asbestos cylinders in place.

When a current of electricity is sent through the wire, the cores H are heated as usual, and also magnetized, and as the magnetization extends more or less to the body E, a certain amount of heat is generated in the latter by electrical currents or molecular motions induced thereby in addition to the heat generated by resistance of the wire and conducted by the metallic cores into the said body. Thus the electric current is made to produce heat in at least two ways, and, as a result, the smoothing iron is very efficient with but a comparatively slight expenditure of generative power.

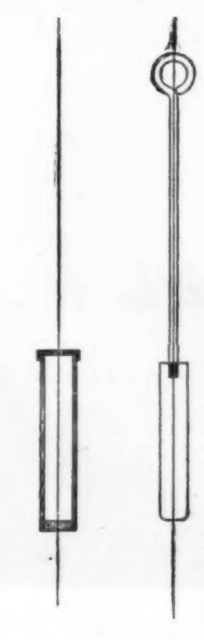
FIRST VISIBLE COLOR OF INCANDESCENT IRON.

DURING the discussion which followed the reading of the paper on "Color Photometry" by Captain Abney and General Festing at the Royal Society, on January 28, some interesting remarks were made by Lord Rayleigh as to the color exhibited by heated iron when raised to such a temperature as only to be just visible in a dark room.

Lord Rayleigh stated that Weber, who, so far as I know, first drew attention to this subject, described the first visible light as a greenish gray. Lord Rayleigh himself repeated the experiment by making a piece of thin iron part of the wall of a very dark room, and heating the iron gradually by a Bunsen burner upon the other side. Lord Rayleigh could not satisfy himself as to the greenish tint, but was satisfied that no redness was apparent.

It struck me that a very convenient method of trying this experiment would be to introduce a round bar of heated iron into a thin sleeve, as shown in the annexed sketch, the sleeve being closed with a cover lined with asbestos. In this way the heat would slowly penetrate the sleeve, and the observers could note the first appearance of visibility and the changes of color that followed.

I accordingly had two sleeves prepared, one of turned and polished iron, the other left with a thick coating of oxide. Two sets of experiments, in each of which six observers took part, were made. In each set of experiments three observations were made with the polished and three with the oxidized sleeve. In each case the observers were in a dark room for some minutes before the experiments began.



In the first set of experiments the observers gave their opinion, at the conclusion of the experiments, as a body, that the first appearance of color was a grayish white; as the sleeve became hotter the color was yellow, and gradually changed into orange. There was little or no difference between the observers as to the instant of visibility; it was generally over a minute before the sleeve became visible, the light generally showing first on the generating line of the cylinder between the eye and the axis. There was no difference in color between the bright and the oxidized sleeves.

In the second set of experiments, the observers had no communication with one another, had no idea what color they were expected to see, and their impressions were written down separately and independently. Their impressions were as follows, the observers being designated by α, β, etc.:

(α) First color visible, gray white, second color white with a little mauve, third pale rose, fourth orange. The above was the first experiment (polished metal). The other experiments showed same color, but no mauve seen. In the last experiment (a very low heat) the color never passed beyond a pale yellow.

(β) For all experiments, first gray white, second yellow, third orange. Last experiment, no orange.

(γ) For all experiments except last, first white, second yellow, third orange.

(δ) For all experiments except last, first gray white, gradually becoming warmer till it reached orange.

(ϵ) First white like phosphorus in the dark, gradually getting to rose, and winding up with a reddish orange not reached in the last experiment.

(ζ) First white with a dark shade, second yellow, third orange; no difference in any of the experiments except the last, where the temperature was lower, and the orange was not reached.

I may add that the temperature of the heating bar was a little reduced each experiment, the colors changed very slowly, and gave ample time for observation.—*A. Noble, in Nature.*

A HATFUL OF WADDING IN A GLASS OF ALCOHOL.

EXHIBIT to the spectators a glass full of alcohol and a high hat filled with wadding, which has been previously well drawn out between the fingers so as to make it assume as great a bulk as possible. Announce that you are going to cause all the wadding contained in the hat to enter the glass of alcohol without a particle of the liquid overflowing.

To this effect, it suffices to take up the wadding in small flocks at a time, and to introduce it into the

EXPERIMENT ON THE ABSORBENT PROPERTIES OF COTTON WADDING.

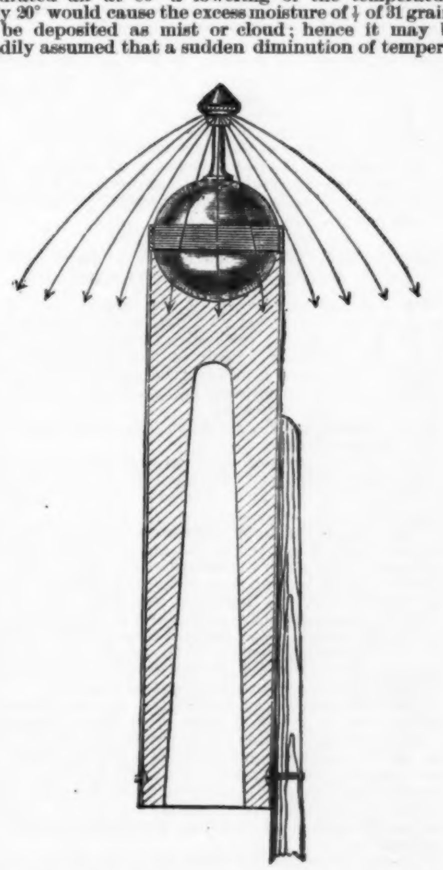
liquid, which it will rapidly absorb. Pack it down progressively at the bottom of the glass, and, to the great surprise of the spectators, you will have performed the experiment announced, without the liquid overflowing, and which you may style: "A hatful of wadding in a glass of alcohol." This property of wadding of absorbing alcohol has been utilized in the manufacture of spirit lamps that may be upset without a single drop of their liquid escaping.—*L'Illustration.*

A PROPOSED RAIN-MAKING ROCKET.

MR. HENRY W. ALLEN, C.E., of Goolburga, India, communicates the following to *Indian Engineering.* The device is a rocket designed with the view of producing intense cold in the upper portion of its flight, with the view of producing rain.

The atmosphere at equatorial temperatures contains generally $\frac{1}{48}$ of its weight of moisture, while in temperate climates only $\frac{1}{160}$; the difference of $\frac{1}{48}$ and $\frac{1}{160}$ equals $\frac{77}{480}$, or about $\frac{1}{4}$ of the weight of the air for a fall of temperature from 80° to 60° Fahrenheit.

A cubic foot of air weighs say 31 grains, so with saturated air at 80° a lowering of the temperature only 20° would cause the excess moisture of $\frac{1}{4}$ of 31 grains to be deposited as mist or cloud; hence it may be readily assumed that a sudden diminution of tempera-



ture to a great extent would be followed by the formation of drops of rain, if not hail. Experiment will probably demonstrate this to be the case, and also as to whether rain once started from a cloud would continue; probably it would with *cumulus* and *nimbus* clouds.

A rocket 4 in. in diameter and 18 in. in length is capable of rising one mile in height.

At the head of the rocket a copper sphere, capable of bearing a pressure of 200 lb. per square inch—internal pressure—is required; the sphere to have a belt of metal with a screw cut on it to enable its being removed from the sheet iron cylinder, which is loaded with composition from above and rammed firmly round a steel

spindle (or hard wood), which forms the hollow necessary for the combustion of the rocket; a small brass tube is screwed into the copper sphere as shown in the sketch, the bottom of the tube being ⅛ of an inch from the bottom of the sphere; the top of the tube is provided with a metallic cap perforated with a number of small holes, inclining downward slightly. When the rocket has ascended nearly its full height, and while passing through a cloud, the ether with which the sphere is charged boils violently, and a very powerful spray is formed, producing intense cold, some 10° below freezing point, while bisulphide of carbon can produce minus 80° Centigrade. To render it safe to use such a large rocket, it is advisable to provide self-acting parachutes. The bottom of the rocket stick can be a tin tube containing a small umbrella; when the rocket falls head downward, a small bullet in the tube releases a spiral spring which shoots out the umbrella, and thus the rocket descends slowly to the ground and can be charged and fired again. Fired when the sun had an elevation of 42°, the production of rain would, even it did not reach the earth, be shown by a portion of a rainbow being formed.

A succession of such rockets would probably cause a cloud to descend which was beyond their range; the long column of cold air would act like a chimney and produce a strong downward current before the cold air had time to diffuse with the surrounding air.

VARIABLE LATITUDE.

AMONG the most important researches which astronomers have in hand at present is an investigation of that period of minute oscillation of the earth's axis which gives rise to the phenomena of variable latitude. At its last meeting in the autumn of 1890, the International Geodetic Union, on the motion of Prof. Foerster, of Berlin, resolved to send an astronomical expedition to Honolulu, for the purpose of making a twelvemonth series of latitude observations, coincident with a like series at the Royal Observatory, Berlin. Dr. Marcuse, of Berlin, and Mr. Preston, of the United States Coast and Geodetic Survey, accordingly went out for this purpose, and the first three months of their work produced substantial results of a most promising character. Upon co-ordinating several hundred determinations of Honolulu latitude with corresponding results at the Berlin Observatory, Dr. Foerster finds that beyond doubt the latitude in Berlin during this period increased by one-third of a second (about thirty feet), and decreased in Honolulu by almost exactly the same amount. So long ago as 1876, Sir William Thomson, in his Glasgow address, presented a dynamical conclusion that irregular movements of the earth's axis to the extent of a half second may be produced by the temporary changes of sea level due to meteorological causes, and this striking result of the Honolulu expedition is to be regarded as observational proof of Sir William Thomson's conclusion. It is to be expected that England will cooperate with the other great nations in carrying out the plans of the International Geodetic Union for the most minute investigation of this fundamental problem in astronomy. As a first effort it is proposed to establish four permanent stations for regular and continued observations of this geographical co-ordinate, at points of approximately equal latitude and on meridians about 90° apart. In this way it is hoped to ascertain the cause of those variations of latitude which have for a long time been suspected at Berlin, Greenwich, and other great observatories, and which could not be wholly attributed to errors of observation. Not only is the research of the first importance in respect to the fundamental observational work in astronomy, but it has exceeding interest in connection with tidal, meteorological, and geological observations and speculations.—*The Nation.*

THE CONNECTION BETWEEN SUN SPOTS AND MAGNETIC STORMS.

WE give an engraving of the appearance of the great sun spots of February, 1892, as photographed by Dr. W. R. Brooks, at the Smith Observatory, Geneva, N. Y. The extreme length of this great group was about one hundred and fifty thousand miles, and the width eighty-five thousand miles. A number of new spots have lately appeared.

In a recent article in *Knowledge*, the editor, Dr. A. C. Ranyard, says:

"We are at present only in a position to observe and collate facts, and we seem to be very far from understanding the great periodic changes going on before us.

"There is evidently a close connection between the development of spots on the sun's surface and the swaying of the earth's magnetic axis. More than one popular writer has spoken of this connection as proving that the sun is magnetic, and that solar storms sway its magnetic axis—and, further, that every motion of the great solar magnet is accurately followed by a corresponding motion of the magnetic axis of the planets, which bow and swing, always keeping parallel with the axis of the great central magnet.

"But the earth's magnetic axis revolves about the earth's axis of rotation once in 24 hours, describing a circle among the stars of nearly 20° radius. If, then, the earth's magnetic axis and the sun's magnetic axis were permanently parallel, we should have to assume that the sun's magnetic axis travels round a line which is not the sun's axis of rotation in a period equal to the earth's period of rotation, which seems highly improbable.

"There is considerable difficulty in conceiving of a hot gaseous body like the sun being magnetic. The difficulty occurred to Sir Isaac Newton, who, in a letter written on the 16th of April, 1681, wrote: 'Concerning the experiment that a magnet loses its magnetism by heat, some have indeed supposed the sun to be cold, but I believe Mr. Flamsteed is not of this opinion, for they may as well affirm culinary fire to be cold. For we have no argument of its being hot, but that it heats and burns things that approach it, and we have the same argument of the sun being hot. Were we ten times nearer him, no doubt, we should feel him a hundred times hotter, for his light would be a hundred times more constipated, and the experiment of the burning glass shows that his heat is answerable to the constipation of his light. . . . The whole body of the sun, therefore, must be red hot, and consequently void of magnetism, unless we suppose its magnetism of another kind from any we have, which Mr. Flamsteed seems inclined to suppose.'

"It is possible that though the sun itself may not be magnetic, it may act as a magnetic body because it is surrounded by a magnetic envelope or region where its gaseous constituents are precipitated into solid or liquid magnetic particles. During the past year Professor Dewar has shown that oxygen becomes strongly magnetic when liquefied at a temperature of —180° C. The vapors of iron when precipitated in the comparatively hot lower regions of the corona would also form a cloud of magnetic fog or dust. There is some evidence, in the forms of the coronal streamers seen in the neighborhood of the sun's poles, that the coronal particles are magnetic, and tend to arrange themselves along lines of force, as if the whole sun had a magnetic axis, nearly but evidently not accurately coincident with the sun's axis of rotation.

"The corona is far from being accurately symmetrical with respect to the sun's axis of rotation; it is denser in parts, and has projecting rays or structures which extend to a great distance from the sun, especially in the sun's equatorial regions. On the above theory we should expect to find the magnetic region similarly unsymmetrical, and a body passing around the sun, near to the plane of the solar equator, would be subject to very unequal disturbance from the magnetic particles of the corona. This seems to tally with the facts observed—for the greatest magnetic storms have generally taken place when a large spot has been seen near the center of the sun's disk. We know very little at present as to the connection between the corona and the sun spots, or as to how far the corona extends—some of its larger structures may extend as far as the earth's orbit, or as far beyond our orbit as the zodiacal light extends. There is no evidence that large coronal structures exist over large sun spots, but there is evidence of an intimate connection between the general development and arrangement of the parts of the corona and the spottiness of the sun's surface, as well

THE GREAT SUN SPOTS OF FEBRUARY, 1892.

as between the development of large prominences and sun spots.

"The sudden manner in which these magnetic storms commence seems rather to indicate that the earth plunges into a magnetic or auroral region than that the magnetic equilibrium of the whole solar system is suddenly disturbed. There is no brewing of a magnetic storm, it breaks out with full violence from its commencement."

SOPHIE KOWALEVSKI.*

CHARLOTTE C. BARNUM.

MME. SOPHIE KOWALEVSKI (or Sonja Kovalevsky) was born in Moscow, Dec. $\frac{15}{27}$, 1853. Her father, Gen. Corvin-Krukowsky, was a man of marked ability and a member of the old aristocracy, being a direct descendant of Mattias Corvin, king of Hungary. Her mother belonged to the Schubert family of mathematicians and astronomers, and was herself an unusually gifted woman. Sophie's father retired from active service while she was very young, and took up his abode at his ancestral castle at Palibino, a lonely spot which, at certain seasons, was entirely cut off from the outside world. She began her studies under an English governess. A little anecdote of her childhood has found a place in several learned journals, but the moral is slightly obscure. When she was ten years old, the castle was repapered, but when the paper came from St. Petersburg, it was found that there was none for the nursery. For this room was used a lithographed course of Ostrogradski on mathematical analysis, a survival of her father's student days; and, to the despair of her governess, she was continually reading these mathematical dissertations covered with incomprehensible hieroglyphs. When, at the age of sixteen, she began to study calculus, her professor was astonished at the quickness with which she understood him, "just as if it were a reminiscence of something you knew before," he told her. The continual reading of the wall paper had left some unconscious traces on the child's mind.

From eight to fifteen years of age, her tutor was Mr. J. Malevitsch, a fine teacher, who, under the wise supervision of her mother, devoted himself with zeal and success to her education, and exerted a marked influence on the rapid development of her brilliant powers. Her literary ability was so marked that her tutor predicted for her a brilliant future as a writer, and he was not mistaken in his estimate of her powers in this line. Her *Reminiscences of Childhood*, translated into Swedish and Danish under the title, *The Rajewsky Sisters*, is spoken of in *Nature* as "one of the finest productions of modern Russian literature," and its publication was welcomed in Russia, Sweden, and Denmark as an event in literature, and it was said a new Tolstoi had been born in Russia.

Her special interest in mathematics was awakened by her uncle Schubert, and she chose that specialty in her fourteenth year. She had studied by herself a text book on physics, found among her father's books. The author, a friend of her father's, was once visiting him at Palibino, when Sophie told him she had studied his book. He laughed and said it was impossible, as she did not know trigonometry. But it appeared in course of the conversation that the girl, from the knowledge she then possessed, had deduced in her own way the fundamental formulæ of trigonometry. Astonished at so remarkable a proof of her intellect, the visitor urged her father to have her talent cultivated in spite of the aristocratic and conservative view of the education suitable for a lady of high rank. Her father thinking her passion for the study was only a caprice, readily consented, and she was allowed to study a year at St. Petersburg. But when, at the age of fifteen, she seriously asked permission to study in a foreign university, there was a terrible scene in the family. Her father could not have taken it more to heart if she had committed a grave fault.

In order to understand what follows, it is necessary to remember that at that time in Russia a girl who studied was considered a nihilist. There was indeed a political and patriotic enthusiasm in the burning desire for study which had seized the rising generation. It was a wish to impel their beloved country toward the light of liberty. This enthusiasm had produced a curious phenomenon—marriages contracted for the purpose of freeing the girl from her father's authority and giving her the chance to study abroad. For this reason Sophie Corvin-Krukowsky, at the age of fifteen, married Vladimir Kowalevski, legally, but with the understanding that both should be free to devote several years to study. With her husband, her sister, and a friend, she went to Germany, and he entered one university, while the three girls went to the only German university open to women, that at Heidelberg. The University of Berlin was so tightly closed that when, a few years later, she was a professor at Stockholm, and wished to attend a course of lectures at Berlin, she was refused permission, and finally obtained admittance only by the direct intervention of the minister of education as a great personal favor.*

After a year at Heidelberg she went in the autumn of 1870 to Berlin, and timidly asked Weierstrass for private lessons, as she could not be admitted to his lectures. He thought at first that the girl would become only a *dilettante* in science, and he did not wish to waste time teaching her. But during the conversation he discovered in her such wealth of ideas, and so remarkable an intuitive grasp of the more difficult questions of the science, that it became a pleasure for the great mathematician to instruct her. Four years she spent as his private pupil, her studies being interrupted only by a visit to her family in Russia and by some other trips. Being unable to obtain a degree at Berlin, she took the oral examinations at the University of Gottingen, presented a remarkably original thesis "On the Theory of Partial Differential Equations," and obtained the degree of Ph.D., being the second woman to receive this degree at Gottingen.

Her husband received his degree at the same time, and was appointed professor of paleontology in the University of Moscow, where he soon attained a position of distinction among the paleontologists of the world. She was twenty-one when they returned to Russia, and established their home in Moscow. With her enthusiastic temperament, she devoted herself completely to whatever work she undertook. At first her home duties absorbed nearly all her time and thought. Then she took up her husband's specialty with such success that for some time, while he was otherwise occupied, she wrote his lectures for him. Then, being in a literary atmosphere, her taste for literature revived, and she wrote a novel entitled "The Private Teacher," dealing with university life in Germany, and published it anonymously in a Russian journal. Thus passed several years of rare domestic happiness in their beautiful home in Moscow.

Professor Kowalevski was full of grand ideas and of enthusiasm, but exceedingly visionary. He fell under the influence of an adventurer, who drew him into dangerous speculations in petroleum wells and other industrial enterprises. She used all her efforts to break the spell of this false friend, but the fever of speculation was too strong, and he risked all his inheritance and his wife's and lost. Although he had committed no crime, he felt the disgrace so keenly that he left his home and position to resume his solitary studies abroad. Probably his mind had become unbalanced by their financial ruin. Soon came the startling news that in a fit of despair he had committed suicide. Thus the burden which had proved too heavy for him fell upon her alone, together with this great additional sorrow. Her parents were dead, her wealth had been thrown away, and as soon as she recovered a little from the shock of the tragedy she found herself for the first time forced to consider the question of money. She must support herself and her four-year-old daughter. In Russia the best she could do was to teach arithmetic to one of the lower classes in a girls' school. Then came in the autumn of 1883 a signal illustration of the liberal spirit and kindness which mathematicians and astronomers almost invariably show to the women working in their departments. Mittag-Leffler, who had also been a pupil of Weierstrass, was at this time organizing the University of Stockholm, and, although she had published no mathematical work dur-

* Read before the Mathematical Seminary of Johns Hopkins University, Jan. 6, 1892.—*Astronomy and A. P.*

* An American girl, Miss Ruth Gentry, the holder of the European fellowship of the Association of Collegiate Alumnæ, is, however, now attending mathematical lectures at the University of Berlin, where she says she is shown "all the courtesy and kindly consideration" she could wish.

ing the nine years since she had left Germany, he invited her to deliver at Stockholm a course of lectures on partial differential equations. Meanwhile he succeeded in obtaining the money necessary to establish and sustain a chair of higher mathematics created especially for her. She lectured the first year in German, afterward in Swedish. Her clear, inspiring teaching, her intellectual ability, and her personal popularity attracted to her classes many able students, some of whom were already professors. In 1885 she was made associate editor of *Acta Mathematica*, and later was elected corresponding member of the Royal Academy of Science of St. Petersburg. The French Academy proposed as the subject for the Bordin prize in 1888 the problem "To complete in an important point the theory of the motion of a solid body." The commission not only unanimously awarded her the prize, but upon their recommendation the amount was increased from 3,000 to 5,000 francs on account of the "extraordinary service rendered to mathematical physics by this work." She traveled in all parts of Europe, making friends wherever she went, and continued to fill her position at Stockholm until February of last year. After only four days' illness she died of pleurisy, Feb. 10, 1891, at the age of thirty-seven.

Her mathematical works consist of the following papers:

I. On the Theory of Partial Differential Equations (Thesis for Ph.D.)—published 1875. *Journal fur die reine und angewandte Mathematik*, vol. lxxx., p. 1 (32 pp.)

II. On the Reduction of a certain class of Abelian Integrals of the Third Rank to Elliptic Integrals—published 1884. *Acta Mathematica*, vol. iv., p. 393 (22 pp.)

III. On the Propagation of Light in a Crystalline Medium—published 1884. "*Ofversigt af svenska vetenskapsakademiens forbandlingar*, vol. xli., p. 119 (3 pp.)

IV. On the Propagation of Light in a Crystalline Medium—published 1884. *Comptes Rendus*, vol. xcviii., p. 356 (2 pp.)

V. On the Refraction of Light in Crystalline Media, —published 1885. *Acta Mathematica*, vol. vi., p. 249 (56 pp.)

VI. Remarks and Observations on Laplace's Researches on the Form of Saturn's Rings—published 1885. *Astronomische Nachrichten*, vol. cxl., p. 37 (12 pp.)

VII. On the Problem of the Rotation of a Solid Body about a Fixed Point—published 1889. [Résumé of IX.] *Acta Mathematica*, vol. xii., p. 177 (56 pp.)

VIII. On a property of the system of differential equations which defines the rotation of a solid body about a fixed point—published 1890. *Acta Mathematica*, vol. xiv., p. 81 (13 pp.)

IX. Memoir on a particular case of the problem of the rotation of a heavy body about a fixed point, where the integration is effected by the aid of the hyperelliptic function of the time—published 1888. *Recueil des Savants etrangers*, vol. xxx., p. 1 (66 pp.) [This is the work crowned by the French Academy.]

X. On a theorem of Mr. Bruns. *Acta Mathematica*, vol. xv., p. 45 (19 pp.)

She wrote seven literary works:

I. The Private Teacher, published anonymously as an appendix in a Russian journal.

II. Reminiscences of George Eliot. *Rousskaia Mysl* (Russian Thought), July, 1885.

III. Vae Victis. Novel published in Swedish in the journal *Jul Almanack*, 1889.

IV. Recollections of Childhood (in Russian), 1890. *Vestnik Europy* (Messenger of Europe), vols. 7 and 8, 1890.

V. The Rajevsky Sisters. 1890. The same as IV., but published in the form of a novel in Swedish and in Danish.

VI. The Family of the Vorontsoffs. 1890. Novel in Swedish under the pseudonym of Tanja Rajevsky. It was left complete in manuscript, and the first chapters had been published in the Swedish journal, *Nordisk Tidskrift*.

VII. The Struggle for Happiness. 1890. Under this title two dramas were written jointly by her and Anna C. Leffler (wife of P. de Pezzo, duke of Cajanello, who is professor of higher geometry in the University of Naples).

In her thesis on partial differential equations, Mme. Kowalevski extended Weierstrass' method of proving the existence of an integral of a given system of ordinary differential equations, and proved the existence of an integral of a given partial differential equation. Also she showed in general that the original functions can be expressed in a series of integral powers of the independent variable convergent within a determinate circle, and discussed carefully the case in which this series becomes divergent.

The Commission of the French Academy, before they knew the name of the author, gave the following summary of the memoir which received the Bordin prize: "This remarkable work contains the discovery of a new case in which we may integrate the differential equations of the motion of a heavy body fixed by one of its points. The author is not content with merely adding a result of the highest interest to those which we have had transmitted by Euler and by Lagrange. He has made, from the discovery which we owe to him, a profound study, in which are employed all the resources of the modern theory of functions. The properties of the theta functions of two independent variables permit of giving the complete solution in the most exact and elegant form; and we have thus a new and remarkable example of a mechanical problem, in which these transcendental functions occur, whose applications have been hitherto limited to pure *analysis or to geometry*." The president of the Academy, M. Janssen, in announcing the decision of the commission, said, "Our associates of the section of geometry, after examining the memoirs presented in competition, have recognized in their work, not only the proof of a knowledge extensive and profound, but also the mark of a great inventive mind."

In Kronecker's editorial in *Crelle* we find the following general estimate of Mme. Kowalevski: "She united with an extraordinary talent, as well for general mathematical speculation as also for the technical knowledge necessary in special researches, tireless industry; and, in spite of the most intense activity, in her specialty, her mind was always open to other intellectual interests, and she preserved always therewith her womanliness, and gained and held also the sympathy of those who stood outside the circle of her special knowledge. The history of mathematics will have to speak of her as one of the most noteworthy lights among the class of original investigators everywhere extremely rare. While her memory will endure in the entire mathematical world through her published works (not numerous indeed, but very valuable), the memory of her remarkable and charming personality will live on in the hearts of all those who had the pleasure of knowing her."*

OSCAR WILDE.

THE latest addition to the noble company of playwrights is Mr. Oscar Wilde, whose very successful debut in his new role was awaited by many with as much curiosity as interest. Just now, too, all Paris is on the *qui vive* for his play of "Salome," founded on sacred history, and written solely and originally in French by this most versatile of geniuses, though whether or no he is to reap fresh laurels thereby remains to be seen. Mr. Oscar Wilde is, as every one knows, the younger son of Sir William Wilde, the celebrated Irish oculist; and of his clever wife, whose *nom de guerre* of "Speranza" will be well remembered by all who have any cognizance or recollection of the Young Ireland movement, but who of late years has turned her attention more to folk lore than to politics. Mr. Wilde's career has been a varied and a brilliant succession of *tableaux vivants*, so to speak, from the commencement, as winner of the Newdigate at Oxford, and leader of the then infantile æsthetic craze, to his present semi-public position as lecturer, man of fashion, wit, poet, novelist, essayist, and dramatist all in one. His lecturing tour in America was literally a species of royal progress, even "God Save the Queen" being played to mark his entry into a ball room. Perhaps his most remarkable attribute, after his mastery of paradox and skill in epigram, is the imperturbable and courtly serenity which characterizes his every speech and action. Mr. Wilde was married, some eight years ago, to Miss Constance Lloyd, daughter of Mr. Horace Lloyd, and is the father of two very beautiful boys. His house in Tite Street, Chelsea, was decorated by

OSCAR WILDE.

the late Mr. Godwin, and is, with its subtile harmonies of green and blue, its peacock-like charm of coloring, and quaint, old-world furniture, strangely in consonance with the spirit of modern art and its somewhat *fin-de-siecle* occupier.

PROFESSOR KOPP.

PROFESSOR DR. HERMANN KOPP died at Heidelberg, February 20, 1892, in the seventy-fifth year of his age. He was the son of Joh. Heinrich Kopp, M.D., a physician of considerable reputation, and was born in Hanau, October 30, 1817. After studying natural sciences at the universities of Heidelberg, Marburg and Giessen, he was connected with the latter as lecturer (1841), professor extraordinary (1843) and professor of physics and chemistry (1853) until 1864, when he accepted a similar position at the University of Heidelberg, retiring from the chair in 1890. His researches were mainly devoted to chemical physics, such as atomic volume, crystallography, isomorphism, boiling point, specific gravity, the relation of chemical composition and physical properties, etc., the results of his labors having been mostly published in Poggendorff's Annalen and in the Annalen der Chemie und Pharmacie (Liebig's). Of the latter periodical he was co-editor with Liebig, Woehler and others from 1851 to 1871; from 1847 to 1862 co-editor of the Jahresbericht der Chemie, and one of the contributors to the Handworterbuch (1842–1861). Aside from his important labors in the laboratory and in connection with the publications indicated, his historical studies are of pre-eminent value. His history of chemistry appeared in 1843 to 1847, in four volumes, and was followed from 1869 to 1875 by three volumes of contributions to the history of chemistry; in 1873 by a stately volume treating of the development of chemistry in modern times, and in 1886 by two volumes on the history of alchymie. As a teacher Kopp was highly appreciated, not only for his eminent knowledge, but likewise for urbanity and kindly interest in his students.

* NOTE.—The above paper is founded on the following four sketches, all published in 1891: *Annali di Mathematica, Milano*, 1891. vol. xix., No. 3, pp. 201-11. By Anna C. Leffler, Duchess of Cajanello.—*Rendiconti del Circolo Matematico di Palermo*. Vol. v., No. 3, pp. 121-28. By Mme. R. de Kerbedz.—*Journal fur die reine und angewandte Mathematik, Berlin*, 1891. Vol. cviii., No. 1, p. 88. Editorial by Kronecker.—*Nature*, Feb. 19, 1891, pp. 375-6. The following are promised: Sketch with portrait in *Acta Mathematica*.—Continuation of *Reminiscences of Childhood*, from the date of her marriage. Edited by Anna C. Leffler, Duchess of Cajanello.

PERU: ITS COMMERCE AND RESOURCES.*

By F. A. PEZET.

THE history of Peru is a subject which has more than once been brought before the English-speaking world by authorized persons. Everybody at this advanced age knows perfectly well how Peru was discovered and conquered by the Spaniards, and how, after nearly three centuries of oppression, the country threw off the Spanish yoke, and established itself as an independent republic. In the brief space of time which I have at my command, I will not tire you with reminiscences of an historical nature; my object in appearing before you here to-day is to try and interest you on behalf of my country. I come to you not as a Peruvian, to praise or advertise Peru, but as a friend of England and Englishmen; to prove that Peru is really what the many and learned historians, geographers, travelers, and writers in general have represented it to be—a country of great natural resources, with every possible condition to attain a commanding position among the nations of the world.

On the past riches of Peru I need not detain you. Guano and nitrate; these two words speak volumes, and can be considered as synonyms of wealth. I want to bring you to realize the present condition of the country, and its prospects for the future. Here we have a large country covering a surface of about 500,000 square miles, with a scanty and scattered population of 3,000,000 inhabitants. The last official census of Peru was made in 1876, and the returns showed a population of 2,699,945 inhabitants. But this figure is below the real number, as it has been ascertained that the census commission did not take into account the savage and semi-savage tribes of the mountain regions, and that in some places of the interior their work was very difficult through the ignorance of the people respecting the formation of the census, it being generally believed that the information required was for the purposes of taxation, a thing which the Indian greatly dreads. Although it is very difficult, if not impossible, to make a correct statement as to the uncivilized population of Peru, yet I consider that 350,000 would not be an exaggerated figure. Making allowances for the natural increase since 1876, and also for the decrease in consequence of the war with Chile, I will put down the absolute population of Peru to-day at about 3,000,000 inhabitants.

The aboriginal or Indian race which populated the country, to the extent of some 12,000,000 souls, when the Spaniards conquered Peru, still holds its own, although it has to a great extent degenerated through the miseries which, during centuries, it endured at the hands of its conquerors. The Indian race represents to-day about 57 per cent. of the entire population. In the interior of Peru it has kept in many places quite pure, not having mixed with any of the other races which have been brought into the country. There are tribes existing to-day with the old Incasic Indian features and characteristics quite distinct, and among these people there is a great and natural intellect. The other great race is the European or white, imported from Spain at the time of the conquest, and which has been ever on the increase since then. It represents today about 20 per cent. of the population, and is spread over the whole country in general, but specially on the coast.

As the Peruvian Indian was made to slave at the mines for his Spanish master, the Spaniards had to introduce Africans into Peru in order to till the ground and work on the cotton and sugar estates along the coast, and thus it was that the black race was brought into the country. Slavery having been abolished in Peru, in 1854, no more Africans have since come into the country. So the race has confined itself to some of the agricultural districts, and is now rapidly dying out. In its place there are the "Mestizo" and "Zambo" cross breeds of blacks with whites and with Indians. The cross breed of whites with Indians has produced the "Cholo" race, which of all the castes is to-day the most numerous. These mixed races represent about 23 per cent. of the entire population, together with some 50,000 Chinese imported into the country since 1854, as agricultural laborers. The greater part of these have settled for good, and not a few of them have embraced the Christian faith and married with Indians, Cholas, Zambas, Mestizas, blacks, and whites, thereby forming a diversity of new castes.

This immense country contains rich agricultural and pastoral lands, abundant mining wealth, vast petroleum fields, virgin forests, with every description and variety of timber. Its climate is as good as its soil is luxuriant.

The arid coast, the mountain ranges, and the fertile plains of the east have each a different climate, and in each region the European can find the temperature of his choice. The heat is never too excessive or lasting, and the cold can always be more or less avoided. The reports of the different commissions which within the last two years have visited Peru agree all on one point, and that is that the country is admirably suited for European immigration on a large scale.

And here I come to the first and most important question for the development of Peru—immigration. Peru requires, and must have, not only skilled labor, but above all, agricultural laborers. If the wealth of the country is to be turned to account, capitalists must make up their minds that their first step must be toward promoting an emigration current into Peru.

I do not intend to say that Peru in preference to any other country should be favored by European emigration, no; but what I do insist upon is that Peru, on account of its great natural wealth and its climate, offers a greater inducement to European settlers than perhaps any other South American country. In order to have an exact idea as to this, I will beg you to follow me on the map of Peru (kindly lent by the Peruvian Corporation, Limited). As you can see, Peru is situated between parallels 3° and 19° S. latitude, and between 68° and 81° 20' 45" W. longitude. The exact boundary lines of Peru are not yet thoroughly defined, and this question is still the subject of international controversy, although the various governments of the neighboring states, as likewise that of Peru, are all agreed upon the necessity of arriving at a final settlement.

The country is divided into five distinct zones, which

* From the Journal of the Society of Arts, London.

are formed by the two Cordilleras or chain of mountains nearly parallel to each other which traverse Peru from south to north. The coast, called *la costa*, is the zone which lies between the western chain, called Cordillera de la Costa, and the Pacific Ocean; it is formed by an inclined plane from 30 to 60 miles in breadth, composed chiefly of sandy deserts, nearly destitute of vegetation, with several valleys, through which small streams run into the Pacific, affording the means of irrigation, as on these sandy plains—in fact, over all this zone—it seldom rains.

La Sierra, or second zone, is the country which lies at a height of from 4,500 to 9,000 feet above the level of the sea. It commences on the western slope of the coast range, and also comprises all the country between both great chains. Its width varies from 60 to 120 miles. The chief characteristic of this zone is its temperate climate. Rain falls in great abundance during six months of the year—from October to April—but, notwithstanding this, the seasons, summer and winter, are the same as on the coast, with this difference, that the little rain and mist characteristic of the coast is only to be seen between May and September.

La Puna is the name given to the third zone, which many geographers consider part of the Sierra. The Puna is virtually the high table lands or plateaus of the Andes, at a height of from 10,000 to 14,000 feet above sea level. Lake Titicaca, situated at 13,000 feet above the level of the sea, is one of the characteristics of this zone.

Cordillera is the zone formed by the mountain peaks of the Andes. It is perpetually covered by snow, but has patches here and there, where a kind of pasture grows, on which the vicunas and alpacas feed. Both the Cordillera and La Puna might well be comprised in the Sierra; but, as Professor Raymondi, Peru's great geographer and traveler, sets them up as distinct and separate zones, I have thought it wise to follow his plan.

La Montana, or Region de los Bosques—"Forest Region"—is all the country which, commencing on the eastern slope of the Cordillera, extends far away eastward to the banks of the great rivers Amazon, Ucayali, Maranon, Pancartambo, Madera, and beyond them into Brazil. Each of these zones having special characteristics, it is easy to see that they must have great diversity of climate, and that their resources in the vegetable, mineral, and animal kingdoms must be as varied as they are profuse.

As already mentioned, in the Costa it seldom rains, specially in the northern extremity in the department of Piura. The explanation of this phenomenon appears to be that the prevailing easterly winds, supposed to be a continuation of the southeast trade winds, blowing across the continent, bring the clouds to the higher ranges of the Andes, by which they are broken, and the rain falls before reaching the coast. In Lima the thermometer has never been seen below 60° at noon, and very seldom above 80°. The coolness that pervades the coast of this tropical region can be attributable to its snow-capped mountains, but is rather the effect of a thick mist called *garua*, which covers, at times, the disk of the sun, and is partly owing to a cold current that flows northward from the Straits of Magellan to Cape Parinas.

The difference between the ordinary temperature of the ocean in these latitudes and that of the currents is, according to Humboldt, at least 9°. In all this zone the sun is scarcely ever hidden by clouds for a day throughout the whole year, and the cool southeast breezes temper the heat of the sun to such an extent as to make this region most habitable to Europeans.

The high plateaus of the Andes and the whole of the region which constitutes the Sierra contain, according to various travelers, among the most salubrious spots in the globe. The clearness of the sky and the purity of the air has made the Peruvian Sierra the great health resort of the Southern Continent.

The Montana has two distinct seasons—the dry season, from May to October, and the rainy season, from November to April. During the dry season, the heat is greater than in any other part of Peru. The mean annual temperature of the Amazon valley, from Manaos to Tabatinga, is 80°. Moyobamba, which stands 2,700 feet above the sea, has a mean annual temperature of 77°. Chachapoyas, situated 7,600 feet above the sea level, has a temperature ranging from 40° to 70°. Although the Montana is traversed by a great many rivers, and the greater part of its virgin woods have not been explored, still the climate has been most favorable to the foreigners who have settled there and traveled through this region. The few cases of malaria and such fevers as are always associated with rivers, swampy forests, and uncultivated lands being almost confined to the smaller rivers, and quite rare on the banks of the Amazon, Maranon, Perene, Ucayali, and Palcazu.

Taking the country at large, it cannot be said to be unhealthy, it being a well known fact that the great epidemics have never caused the number of victims in Peru as they have elsewhere. Cholera has never appeared in Peru, though it has raged very severely in the neighboring countries. Yellow fever, that great scourge of nearly every tropical climate, has paid Peru few and far between visits, but even then its number of victims compares favorably with those of other countries; and, what is more important, its last visitation, in 1881, was of small duration and compared even more favorably with 1868 than that year's did with the great plague of 1854.

In some of the valleys there is, to a great extent, a sort of ague called *terciana*, arising principally from the marshes, but this illness cannot be considered as a serious one, and now it is generally combated with undoubted success by the most insignificant of local practitioners.

If old age is a test for a country's salubrity, then it must be confessed that Peru is really healthy, as not only among natives do people attain a ripe old age, but many foreigners, settled in different parts of the country, have lived to ages considerably above sixty.

Accepting the salubrity of the country and its suitability for Europeans, the first and natural question which arises is, To which zone of this country should Europeans go?

In order to answer this, I must first give an account of the natural resources of each zone, or, at least, of the Costa, Sierra and Puna, and Montana, as I do not suppose any one would choose the snow-covered peaks of the Andes, the Cordillera zone, as a likely place to emigrate to.

By reason of the climatological and geological conditions of Peru, likewise of its great heights, distribution of the waters of its great rivers, and aridness of its coast, the three kingdoms—animal, vegetable, and mineral—are represented in each and all of the zones by special characteristics, which constitute of themselves undeniable sources of wealth.

The animal kingdom is represented in the Costa by the following live stock: Horn cattle, goats, horses, mules, donkeys, wool-bearing animals, pigs, various breeds of dogs, deer, rabbits, vizcachas (a kind of hare), cats, and others. There are also partridges, pigeons, cuaresmeros (a kind of ruff), and many other game birds, as well as ducks, geese, turkeys, fowls, innumerable sea birds, and a great variety of good fish, both of salt and fresh water, the principal being *corbina*, which is one of the best fish extant; the *pejerey* (king fish), an extra superior quality of smelt; *camarones*, *bonito*, *raya*, *pampano*, *lenguado*, *lisa*, and others, which are more or less familiar to Europeans as prawn, skate, sole, plaice, and haddock.

In the Sierra and Puna there are the vicuna, huanaco, llama, alpaca, all wool-bearing animals; also tigers, bears, wolves, panthers, jaguars, and other wild beasts; condors and other birds of prey. In the lower parts of the Sierra large stocks of cattle and sheep are raised. The animals found in the Montana are a variety of wild beasts; also horses, cattle, pigs, deer, rabbits, and wild hogs; the chinchilla, the nutria, and other fur-bearing animals; turkeys, pheasants, ducks, fowls, pigeons, geese, birds of paradise, and as great a variety of humming birds as are to be found in any part of the world, game birds unknown to the European; and also a large variety of reptiles, alligators, and fish of many kinds in the full flowing rivers. The *fauna Peruviana* has been well studied by Professor William Nation, an Englishman, who has lived in Peru for a great many years. Up to 1881 he had catalogued 40,000 different specimens, including birds of passage.

The vegetable kingdom of the Costa has as principal products: Sugar cane, rice, cotton, bananas, maize, vine, alfalfa (a kind of lucern, or luxuriant clover), olives, tamarinds, potato and sweet potato, all kitchen vegetables, and every kind of tropical fruits, as well as other indigenous ones.

In the Sierra, the products of the temperate zone, and many of those of the torrid zone, are cultivated, and, in fact, anything and everything may be cultivated in this privileged region. However, its principal products are potatoes, a plant indigenous to Peru, which grows wherever planted, and even in a wild state. The primitive potato is about the size of a hazel nut; and it is to the aborigines of Peru, who, by careful cultivation, developed it, that the world owes one of its principal food roots. Wheat, barley, oats, alfalfa, maize, or Indian corn, which grows nearly everywhere, and, in some places, yields two crops a year. It supplies a staple of life for all classes, and not only affords food, but serves to make the national beverage, *chicha*. Yucca, rhea, or ramie, tobacco, coffee, cocoa, chinchona, cane, castor oil plant, and a very large variety of fruits, grains, and medicinal plants grow, wild and cultivated, in this zone.

The principal staples of the mountains are caucho, or India rubber, which is exported *via* Brazil, by the river Amazon, tobacco, sarsaparilla, ivory nuts, chinchona, coca, coffee, cocao, cane, and every tropical product known. The forests abound with valuable timber, woods, and plants, among which are found rare wood, for cabinet work, medicinal and oleaginous plants, dyewoods and textile plants.

On the cold, bleak Puna the few crops that grow are the ichu, on which the wool-bearing animals indigenous to this region feed; barley, oats, quinua, olluco, oca, and other indigenous roots, which the natives use as food and for medical purposes.

Rich as the agricultural wealth of Peru is, it is as nothing when compared with the resources of the mineral kingdom. Providence, with a lavish hand, has hidden away in those great ranges of mountains which form the Andes, and on their slopes, both eastern and western, as in the sandy hills and plains of the coast, and in the beds of the torrents and rivers in the Montana, all and every description of minerals, fossil substances, oils, and even precious stones.

The Costa is rich in petroleum, silver, copper, coal, sulphur, salt, guano, nitrate, lime, magnesia, borax, and gold is found in many places.

The Sierra is undoubtedly the region where the great mineral wealth of the country lies. The Andes can be said to be the gigantic monument raised by the hand of Nature to Mammon. Within those mountains are hidden the treasure which many struggle for; it was the sight of those treasures which made Spain, that great power of the sixteenth century, destroy an ancient empire, and cause to disappear a civilization the like of which had never been seen or heard of. And yet to-day, when we come to consider that Spain during three centuries only managed to scrape the surface of those rocks, notwithstanding the fact that the value of the silver which the conquerors extracted amounted to something like £180,000,000 sterling, it shows how remarkably rich the country is; none of the mines having been worked on a very large scale, owing to the backward state of the mining industry in those days. It is believed by mining experts who have visited some of the principal silver districts of Peru that the amount of high grade ores extant, nearly on the surface of the mines, or which can be extracted at a small cost, amount to considerably over 2,000,000 tons, while the poor or low grade ores which have been piled outside the mines worked by the Spaniards, and which, with modern appliances, could be treated with undoubted success, represent many hundreds of thousands sterling. The Peruvian press and the Peruvian miners at large have lately been much excited over an invention of Senor P. F. Remy, a Peruvian mining expert, who professes to have found a new method for the treatment of blende, one of the most refractory ores, and which abounds greatly in Peru. Until now miners did not know what to do with such ores, the result being that they were turned aside and left there;

but to-day, when Mr. Remy affirms that he has discovered the means of turning such ores into account, Mr. Gamboni, an Italian mining expert, challenges the priority of the invention, and actually states that he has an invention of his own for the treatment of the same ores. Both methods give the same result, but they differ one from the other in detail. According to last accounts it appears that Senor Remy proposes that an independent committee should study both processes, and that its decision should rule. Mr. Gamboni does not accept this, claiming that when Mr. Remy applied for his letters patent he had already patented his invention, and he further argues that Mr. Remy's so-called invention is only an application of his own.

But I have digressed from my main point. To return to my subject, I will just name the principal minerals which are to be found in the central region of Peru: Silver, copper, gold, lead, cobalt, cinnabar, antimony, coal, salt, iron, nickel, marble quarries, arsenic, sulphur, alum, and petroleum.

In the Montana the gold washing and gold mines are the special feature; there are also known to exist emeralds, rubies, turquoises, and diamonds, in the eastern rivers, as the Incas used such precious stones to adorn their garments with.

By the preceding enumeration of the resources of the three kingdoms, it is obvious that Peru has been favored with more than an ordinary share of the good things of this world, which, from a commercial and practical point of view, constitute a nation's wealth.

Undoubtedly few countries on the face of the globe can present a higher standard of natural resources, and, much less, can any present such resources placed in more suitable localities for the ends of commerce. When we consider the geographical position of the nitrate fields of Peru, the guano deposits, the immense petroleum fields, which lie on the sea coast inviting the hand of commerce and enterprise to carry them across the seas to less favored climes, and we turn our minds to the agricultural resources and find that, notwithstanding the great and natural barrier which divides the coast from the Montana, each zone is favored with outlets for the exportation of their large and varied products, on one side the Pacific Ocean, and on the other the great navigable rivers which empty their waters into the majestic Amazon, which flows into the Atlantic, it is impossible not to recognize the fact that we have before us one of the favored countries of the earth, and one which, if not to-day, to-morrow will force itself upon all men of enterprise.

To some, this may appear exaggeration. You may be inclined to think that my enthusiasm carries me away, or that in my earnest endeavor to serve my country, I trespass upon the limits of your credulity and overrate its resources. If all what I have said had not been already proved to the world at large by distinguished Englishmen and others who have visited the country, I might, indeed, be taken for an optimist, but, fortunately for Peru, and I may say for the commercial world, every one of my words can be confirmed by independent evidence.

Little wonder, then, that this country, notwithstanding the many drawbacks which have served as obstacles to its greater development, should be to-day attracting the financial world in such a noticeable manner as it does, and that it should be considered by many as the land of promise for the overgrowing population of European countries.

Judging from the description which I have just made, you will come to the natural conclusion that Peru offers, in each and all of its different zones, an ample field for enterprise; and that, therefore, the European, from a climatological and commercial point of view, could suit himself in no matter what part of the country.

Undoubtedly this is a fact; but I beg you to bear in mind that, while some parts of Peru have been more or less opened up to commerce and industry, there are others equally as rich, if not richer, where the soil is completely virgin, and where the skill and energy of the European is more necessary than in others. I refer to the transandine region; that is, the eastern slopes of the Great Cordillera and the Amazon valley.

The coast has in itself the necessary elements to be self-supporting. This region has been more or less in actual development since the Spanish domination; and although there is a great scope for the advancement of its industries—notably, the agricultural—still it keeps apace with the general progress of the country. What the coast mostly requires is irrigation and the aid of capital. Its now seemingly arid plains can be turned into rich agricultural lands at a comparatively small cost; and these, properly cultivated, will produce abundance of crops, which will, within a short period, repay capitalists investing in such an enterprise. The sugar, cotton, rice, and vine plantations of the coast could all be made much more profitable, and the production of these, the principal crops of this zone, could be increased within a very short time, if the owners of the estates had the necessary capital to invest in their properties. Unfortunately, many of the owners of the fine cane estates are in very straitened circumstances, owing to the present low price of cane sugar in the European markets, and the heavy losses which they sustained during the war with Chile, when the whole trade and commerce were paralyzed, and to the general depression which followed closely upon that event. Another by no means unimportant factor for such a state of affairs has been the scarcity of labor, which, ever since the importation of Chinese contracted laborers was suspended, in 1875, has caused great prejudice to the agricultural interests at large; and last, but not least, the extravagant manner in which they commenced their business, the costly plant erected, and the anti-economical methods of production employed.

The valleys of the coast, as well as these sandy plains, must all, sooner or later, become great industrial and agricultural districts; and there is already a marked tendency in this direction, traceable to the last few years. Several schemes for the irrigation of these lands are now under consideration and study, and a few of the best estates are being worked on a larger scale than they have hitherto been. The prospects for the coast are even brighter; and, what with the recent discoveries of vast and rich fields of petroleum along the northern coast, this zone has every possible facility for attaining greater prosperity.

The depression in Peruvian agriculture dates since the abolition of slavery, in 1854; this most humane step having been taken during a civil war, and when one of the contending parties was in dire want of fighting men. Until that year the estates and plantations of the coast had been worked by the descendants of the African slaves, who had been imported into the country for the purpose by the Spaniards. These negroes, although a lazy lot, managed to work the plantations fairly well, and there is no doubt but that, up to that time, agriculture was a thriving industry in Peru. During this civil war, the greater part of the slaves were turned into soldiers; and once they had tasted the cup of military idleness and town life, they were incapable of returning to a country life and agricultural work. The cotton, sugar cane, and vine estates, which constituted the agricultural wealth of the nation, were nearly abandoned, thus causing great losses. Each new citizen considered himself equal to his late master, and used the freedom which law had granted him in a most injudicious manner. As if this were not sufficient, Providence willed it that about that time Peruvian guano should be brought to the notice of Europe, and the suddenness of the springing up of this new and extraordinary source of wealth was the cause of the complete neglect of all agricultural interests in Peru. The nigger soon degenerated completely; country life had no longer any attractions for him and his, he yearned after the pursuits of the whites, he learned trades and even professions, and lived in the populated centers, leading, in most cases, a vagabond life; as a soldier he was a perpetual source of trouble and danger to the government, the *pronunciamentos* having generally their origin from among the colored troops.

When the agriculturists of Peru found themselves in such a sad plight, they considered what had best be done in order to save the country from becoming less and less productive, through the want of proper cultivation and care, and they, therefore, sought aid from the government and implored for laborers. The Indian was entirely unfit for such work on the valleys of the coast, where the principal estates and farms were situated. The black and his cross breeds could not be induced to return to a life which reminded them of slavery; and so there was really nobody to do the work. It was then that immigration for agricultural purposes was first thought of, and the first idea was to get Europeans, but having failed to get sufficient supply of these, Chinese laborers, which had proved successful in other countries, were got instead. From 1856 until 1873, if my memory fails me not, whole shiploads of Celestials arrived yearly in Peru. At first very few were forthcoming, but, between 1869 and 1873, their numbers greatly increased, and there were as many as 13,000 imported in one year. These laborers helped in a great measure to revive the agricultural interests of the land; they were contracted for a period of eight years, during which time they were obliged to work for their employer, after which they were free to dispose of their labor. As a result of the impulse which agriculture received at the time, it is well to note that in 1870 Peru exported to this country 251 tons of raw sugar. In 1873 this quantity had grown into 15,950 tons, in 1875 into 50,000, and in 1879 into 71,400 tons. This was the year in which the war with Chile broke out, and, as a sequence to the misfortunes which befell the country, the exports of this most flourishing industry naturally fell in 1880 to 49,503 tons, and in 1884 to 26,565 tons. Since then a favorable reaction commenced to set in, the exports of sugar during each of the last two years to this country having averaged 42,500 tons.

Notwithstanding the immigration of Chinese laborers, the government have ever been trying to obtain a good and constant supply of Europeans, and toward this, several laws have been passed by Congress, and now and again contracts have been entered upon with different companies and persons for the introduction of European laborers into the eastern regions of Peru. A few colonies or settlements have from time to time been established within the territory, composed of Germans and Italians; but, for the most part, the Europeans who have gone to Peru in order to seek a living have given themselves more to trade than to agricultural pursuits, so really Peru, in this respect, may be said to still present an entirely new field for European enterprise.

The Sierra, which, as I have said, is mainly dependent on the mining industry for the support of its inhabitants, like the coast requires the aid of foreign capital in order to achieve that development which its extraordinary mineral wealth demands.

The aboriginal who inhabits this part of the country is of a stolid nature. He dislikes agricultural work, which is generally attended to by his wife and the female portion of the family, while he toils at the mines. It must be borne in mind that, as the Spaniards obliged all the Indians and their families to slave at the mines, they have become accustomed to this kind of work; and so every *serrano* is, by instinct, a miner. He is, as a rule, very quick at learning all practical knowledge proper to his vocation; and, now that the government have established miners' training schools in all the principal mining districts, he is developing a great and natural taste for skilled work. If that horrid *guarapô*, made from the juice of the sugar cane, could be banished from the mining centers, in spite of the many drawbacks which have, since time immemorial, served to degenerate the descendants of a once powerful and civilized race, the *serrano* could yet be made an important factor in the greater development of his country. Unfortunately, the use and abuse of this stuff is ever on the increase; and, while its manufacture enriches a good many cane growers and distillers, its effects are fast ruining a large section of the population. Perhaps, when the country, and its many other resources, are properly worked, new industries will spring up, more thriving, and decidedly more honorable, than the one which, as a Peruvian, I have to deplore, on account of its pernicious effects.

The greater part of the land in this region is owned by the natives themselves. Their wives till the ground and grow maize, yucca, potato, and other indigenous plants and roots on which they mainly live. It is due to these great facilities of existence which they have, that the *serranos* are so careless of everything and so little ambitious; but it is to be hoped that, with the spreading of education and the bringing of these regions into closer contact with the commercial and industrial centers where the whites abound, a change will soon take place beneficial to them.

At present, the number of mines being worked in Peru are comparatively few, when compared with the numbers during the Spanish domination. At that time, every available man and woman was sent to work at the mines. Since the war of independence, the mining industry of Peru has suffered a great deal, and when the guano fever set in, hardly anybody thought of that which had made famous the name of Peru.

To-day, the same as in the agricultural interests, there is a reaction in favor of mining, and every year this industry receives new life and vigor. Its final development will depend on the interest which it may attract from the foreign capitalist and speculator.

The transandine region, or Montana, where everything is exuberant, and where the hand of industry has not yet commercially developed the products of nature, is beyond dispute one of the most favored fields for European enterprise. It is to this virgin region where I would convey you in imagination. Just fancy, for one instant, a region where grow in luxuriance such valuable products as tobacco, sugar cane, rubber, cotton, coffee, cocoa, vanilla, sarsaparilla, copaiba, the vine, oranges and other fruits, herbs and plants, both medicinal and oleaginous, timber and wood of every description; where the rivers are navigable, and on the banks of which some of the richest gold, and diamond, and emerald, and ruby fields are to be found. If this does not come to the expectation of "El Dorado," or does not realize as near as possible the tales of the "Arabian Nights," I do not know what does. And yet this is not a myth, neither is it the dream of a writer of fiction. Mr. Louis Wolff, a German engineer, who has only last year been exploring the valley of the Peruvian Amazon, says that it is his opinion that the gold washings of the Maranon and other rivers, if worked by the hydraulic system, would yield very great quantities of the precious metal. He urges that the Peruvian government should send a scientific expedition to the River Santiago, in order to make a proper survey of these treasures.

Many other Europeans and Peruvians, who have visited that part of the country, speak of its extraordinary wealth; and all who have been there feel surprised that it should not have attained a greater prosperity already.

The government of Peru, fully convinced of the importance of this region, appointed a special commission to report upon it. Their report, which is a most elaborate one, and which does honor to the commissioners, contains many valuable details with respect not only to the resources of the region, but with respect to its many requirements. Among other innovations which they recommend, perhaps the establishment of an agricultural college and of a bank of agriculture deserve the most attention, as they would both be the best means of furthering the plans of the government. The port of Iquitos, on the Amazon, from whence the products of this region are brought to Europe, carries on a very active and increasing trade with the outer world, and is called upon to be, at a not distant period, a very flourishing port.

(To be continued.)

[FOR THE SCIENTIFIC AMERICAN.]

SPRAYING FOR THE PREVENTION OF PLANT DISEASES.

By JOSEPH F. JAMES, M.Sc.

THE wonderful advances that have been made in the treatment of plant diseases is well known to those who have given the subject attention. The origin of the treatments, however, and the rapid extension of the remedies, is not so generally known, and it is the purpose of the present article to give a brief outline of the origin and trace, as it were, the rise of the comparatively new science of treating fungous diseases of plants.

The destruction by poisons of insects injurious to plants antedates the treatment of fungous diseases by somewhat similar means by about ten years. When the Colorado potato beetle crossed the Mississippi River about 1864 and 1865, and invaded Illinois, the greatest consternation prevailed among the farmers. At first mechanical means, such as crushing, sweeping or hand picking were resorted to, but the numbers of the insects were such that it soon became evident other means must be used. Experiments were made about 1869 with various compounds, and still further experiments were made in the following years. In 1872 it was announced that Paris green was an effectual remedy for the potato beetle and other predaceous insects, and then came the problem of applying it. At first it was sprinkled as a powder from a box or can with a perforated lid, but in 1874 Mr. Frank Gray invented a knapsack sprayer for applying the poison in a liquid form. This seems to have been the first spraying machine used for the destruction of insect pests. Since that date innumerable automatic hose or hand sprinklers have been invented. Their use for the prevention of plant diseases began at a later date.

While the application of poisonous substances for the destruction of injurious insects was the result of deliberate action, due to experiment, the use of similar means for the prevention of fungous diseases of plants was purely accidental. From a paper by Prof. Millardet published in Bulletin No. 2 of the section of plant pathology of the United States Department of Agriculture in 1886,* we learn that mildew of grapes, caused by *Peronospora viticola*, appeared in France in 1878. Immediate steps were taken to ascertain a remedy and prevent serious loss; but it was not until 1882 that the remedy appeared. Prof. Millardet in the paper above referred to says that in October, 1882, in passing through a vineyard in Medoc, France, he noticed that along the road the vines retained their leaves while elsewhere they had long since fallen. Examination showed that these leaves were covered on the upper surface with a thin layer of a bluish-white powdery substance. Inquiry of the steward of the chateau, M. Ernest David, revealed the fact that the vines had been covered with verdigris or sulphate of copper mixed with lime to pre

* Report on the Fungous Diseases of the Grape Vine, 1886, pp. 94-95.

vent the grapes being stolen. Marauders seeing the leaves covered with coppery spots hesitated to take the grapes, fearing the presence of poison. The attention of M. David was called to the preservation of the leaves and the suggestion was made that in the salts of copper would be found the remedy for mildew. Objection was at first raised, but finally the matter was taken up, with what success the future soon showed.

This matter is still further referred to in a report by M. Prillieux, inspector-general of agricultural instruction to the minister of agriculture of France, as follows:

"For a long time it has been the custom in certain parts of Medoc, especially in the vicinity of Margaux, St. Julian, and Pauillac, to sprinkle the vines that skirt the railroads with milk of lime, to which is added a salt of copper. Verdigris was formerly employed for this purpose, but, on account of economy, for several years past it has been replaced by sulphate of copper. The purpose of this operation is to prevent children and marauders from picking the ripe grapes which are most easily reached. They are afraid to eat the clusters which hang upon vines spotted with verdigris and discreetly respect them.

"In this manner they treat a border from five to ten vines in width.

"When the mildew developed in Medoc with considerable severity, it was noticed with astonishment that the borders of the vine plots, covered with spots of lime and copper, were less severely attacked by the disease than was the middle, which had not undergone the same treatment. Already in 1882 this very unexpected fact was authenticated in the parts of Medoc most violently attacked; but it was especially last year, 1884, that the preservation of the borders spotted with lime and copper salt appeared with a striking perspicuity; when, around St. Julian in particular, the disease took an extreme intensity and caused the greatest ravages. While the leaves invaded by the *Peronospora* everywhere dried up and fell prematurely along the roads, they continued green and the grapes ripened."*

In 1883 and 1884 experiments were made with the sulphate of copper for the prevention of mildew. The results were so favorable that in May, 1885, Prof. Millardet published the exact composition of the liquid to be used, together with instructions for treatment of vines.

A report of the favorable result of these experiments was not long in reaching this country, and we find a reference to them in the report on "Fungous Diseases of Plants" by the then assistant botanist, F. Lamson Scribner, published in 1885.† It is there stated that the most effectual specific for grape mildew is a solution of lime and sulphate of copper. The formula given is: 18 lb. sulphate of copper dissolved in 22 gallons of water; 34 lb. of lime slaked in 6 to 7 gallons of water; mix together and apply with a small broom, "care being taken not to touch the grapes. This remedy, it is asserted, will not only destroy the mildew but will prevent its attacks." By this report we learn further the remedies in general use at that time. Moisture was recognized as necessary for the development of fungi, and it was asserted that mildew and black rot were prevented by sheltering the plants from moisture, especially dew.‡ White mildew of roses was noted as being prevented by flowers of sulphur; but the ordinary remedy for most of the fungous diseases of plants was to collect and burn the fallen leaves, branches and other rubbish. For the potato disease, it was said, "there is no known remedy."§

This was the condition of affairs in 1885. The following year witnessed a great advance in many respects. The section of vegetable pathology was established and Prof. F. L. Scribner was appointed its chief. In May, circular No. 1 on "Treatment of the downy grape mildew (*Peronospora viticola*) and the black rot (*Phoma uvicola*)" was distributed. This circular was based upon the experiments made in France and Italy the previous year. The remedies suggested for *Peronospora* were five in all. Three of these were composed of sulphate of copper and lime, one of lime and water and the other of kerosene, carbolic acid and glycerine. One of these remedies, made by dissolving 5 lb. copper sulphate in 10 gallons of water, was used to soak the stakes to which vines were tied, as well as a spray for the leaves. Another, now well known as the Bordeaux mixture, but then known as the "copper mixture of Gironde," was as follows:

"In 22 gallons of water dissolve 18 lb. of sulphate of copper; in another vessel mix 34 lb. of lime with 6 or 7 gallons of water. Pour the lime mixture into the copper solution, mix thoroughly, and the compound is ready for use. Placed in conveniently sized buckets, it may be carried through the rows of the vineyard and applied to the leaves by the aid of brooms or wisps made of slender twigs dipped into the compound and then switched right and left so as to spray the foliage.

"This remedy is very highly recommended. It is not necessary to entirely cover the leaves. Care must be taken not to get any of the compound on the berries."‖

This formula is given to show the large amount of copper supposed to be necessary at that time. The later formulas are very materially modified.

The second publication of 1886 was Bulletin No. 2 of the section of plant pathology. This was devoted to the fungous diseases of the grapevine, and in it is given the formula for the "copper mixture of Gironde" and a statement of the action of the remedy, the method of applying and time when treatment should be made to prevent downy mildew. The mode of application is as follows:

"The sprinklings were made in Gironde, in 1885, with a simple broom of heath, which was plunged into a bucket or watering pot containing the mixture. This plan of operating gives satisfaction, so far as the distribution of the substance is concerned, but it has the inconvenience of being somewhat slow, and it requires much hand labor; therefore apparatuses have been devised which permit more rapid operation at a less expense of muscle."¶

* Report on the Fungous Diseases of the Grape Vine, 1886, p. 83.

† Report of the Commissioner of Agriculture for 1885, p. 84.

‡ Ibid., pp. 87, 78.

§ Ibid., p. 83.

‖ Rept. of Commissioner of Agriculture for 1886, 1887, p. 100.

¶ Loc. cit., p. 16.

Among other formulæ given is one for powdery mildew (*Uncinula*), mainly a solution of sulphur. Other diseases treated are black rot, anthracnose, grape leaf blight, and grape leaf spot. For black rot, stated to be the worst disease with which the vineyardist has to contend, the remedies suggested are to gather and rake together in the autumn all the fallen berries and trimmings from the vine, and burn them. Washing the vines with a strong solution of sulphate of iron may assist in prevention by destroying the disease germs. "The only effective method yet discovered, however," it is said, "is that of bagging the clusters of grapes when about half grown. By this means the spores of the fungus are prevented from gaining access to the fruit, or, if they succeed in this, their germination is prevented by the absence of condensed mosture, which is essential to its accomplishment."*

In Appendix A of this report, written by Dr. E. F. Smith, under the head of "Remedies," we read:

"Many remedies have been proposed for grape rot, but none appears to be effective. Perhaps no substance will ever be discovered which can be depended upon to destroy the growing *Phoma* and arrest the rot without at the same time injuring the vines themselves."†

Under the head of "Preventives" only two methods are considered worthy of extended trial. These are "prompt removal and burning of all diseased grapes;" and "protection of the grape clusters from rain and dew." The latter is performed either by bagging the individual bunches or by covering the trellises with cotton cloth or boards.

The report of the chief of the mycological section for 1886‡ contains some of the matter published in Bulletin No. 2, but it also treats of other diseases than those of grapes. The formula for Bordeaux mixture is again given and recommended for downy mildew. A solution of sulphate of copper in water (300 to 500 grammes in 22 gallons of water) is also recommended for trial. Under the head of "Black Rot" the statement is made that: "To-day we know of no more economical and certain means of preventing the black rot than that of inclosing the half-grown bunches in paper bags. Two-pound brown paper bags, costing about $1.25 per 1,000, may be used; these are drawn over the bunches and tied or pinned around the stems."§

Under the head of "Celery Blight," it is suggested that liver of sulphur, 1 to 2 ounces to a gallon of water, might be useful, but the use of solutions containing the salts of copper is not recommended for "hygienic reasons." Finally, for potato rot, Podechard's powder and David's powder are recommended for trial. Both of these contain sulphate of copper and lime.

In May, 1887, was issued Circular No. 3 of the section of vegetable pathology. In this, formulæ for five different fungicides are given. Among them we note that the one for Bordeaux mixture is changed from 18 to 16 lb. of sulphate of copper in 22 gallons of water, and from 34 to 30 lb. of lime in 6 gallons of water. The fact is also stated that some have reduced the amount of sulphate to 3 lb. and the lime to 2 lb. for 22 gallons of water, with good results. It is further recommended that a spraying machine be used instead of a broom for distributing the liquid. It began, also, to be recognized then, that possibly the copper solutions could be used for diseases of other plants besides the grape, and the suggestion is made that they be tried for potato rot and blight and for apple scab.

In July of the same year, Circular No. 4 was issued, and in this treatments of the potato and tomato for blight and rot are suggested. Here again the copper solutions are considered best, and special attention is directed to Bordeaux mixture. The formula is again reduced, this time to 4 lb. of sulphate of copper and 4 lb. of lime in 22 gallons of water.

It is interesting to note the change which had been effected in the short space of two years in the treatment of plant diseases. It was thought, in 1885, that black rot could only be combated by using paper bags and downy mildew, by sheltering with boards or cloth. For potato rot there was no known remedy. But in 1887 downy mildew was successfully treated with sulphate of copper, and black rot was in a fair way to be controlled. Potato blight had met its match, and thenceforward the farmer was to be free from the fear of losing his crop through the attacks of an almost invisible foe.

It is, perhaps, needless to go further into details. Suffice it to say that every year has shown an advance. Every year some new disease is brought under the control of the farmer or fruit grower. Every year the investigations are continued, facts are ascertained leading to a belief of ultimately controlling some formerly virulent malady. Some diseases, such as black knot of the plum, peach yellows, and pear blight, are still without any remedy except the knife, but hope for successfully coping with these and other obscure diseases is by no means abandoned. Much, it is true, remains to be done; but the work of the past is an earnest for the future, and we look forward to the time when the success or failure of farming and fruit growing will not be dependent on the absence or prevalence of injurious fungi or insects, but upon the intelligence and skill of the agriculturist.

In bringing about the present state of affairs, the Department of Agriculture should be accorded a very large meed of praise. It is impossible to calculate the amount of money which has been saved to the country through the recommendations of the Division of Vegetable Pathology. But when we consider that the amount saved to the grape growers alone and from the effects of a single disease in a single season is estimated at from $75,000 to $100,000, some idea may be had of its value.

Let us examine now the actual money value to the country of these discoveries in the treatment of plant diseases. The annual appropriation for the Department of Agriculture is about $3,000,000. Out of this there is now appropriated $20,000 annually for the Division of Vegetable Pathology. The whole amount expended by the division since its organization in 1886 is less than $80,000. Let us see something of the losses from fungous diseases, and what has been saved by successfully treating them.

* Loc. cit., p. 34.

† Ibid., p. 50.

‡ Report of Com. of Agricul. for 1886, 1887, pp. 95–138.

§ Ibid., p. 113.

It has been estimated that from 5 to 12 per cent. of the oat crop of the country is annually lost through the attacks of smut.* Calculating the loss at an average of 8 per cent., the aggregate loss for the years between 1880 and 1890 was the enormous sum of over $162,000,000. It has been further estimated that in some years—1885 for example—from 40 to 50 per cent. of the potato crop is destroyed by rot. The total loss in six of the principal potato-growing States, New York, Ohio, Michigan, Wisconsin, Iowa, and Illinois, in that single year, is estimated at $10,506,963.†

The loss from black rot and mildew of the grape in 1885, in the two States of Ohio and Michigan, estimated at 40 per cent. of the crop, aggregates over $153,000. Such scanty statistics as these show that the loss on the three articles, oats,‡ potatoes, and grapes for the year 1885, was as follows:

Oats	$1,620,000
Potatoes	10,506,963
Grapes	153,000
Total	$12,279,963

The figures are here naturally of very unequal value, but they show that in a single year in only a small portion of the country there was a loss of over $12,000,000 from fungous diseases. This is four times the annual appropriation for the Department of Agriculture, and six hundred times that expended by the Division of Vegetable Pathology.

Statistics are so meager and there are so many elements to be considered in the problem that it is exceedingly difficult, indeed, one might say quite impossible, to estimate the total amount which has been saved the agriculturists of this country by the application of fungicides as preventive measures. This we do know, however, that the amount saved by the work of the Division of Vegetable Pathology exceeds many, many times the total amount of the annual appropriation for work of the whole Department of Agriculture. It is, therefore, to be hoped that the work may be continued, and if the future successes are as brilliant as the past, there will never be occasion to regret the money expended to investigate and combat fungous disease of plants.

The extensive use of the substances recommended by the Department of Agriculture for combating insect and fungous pests has led to an expressed fear that the fruits sprayed by arsenites and copper compounds are injurious to health.

The question has been discussed to a considerable extent in the public prints, and it probably began because of the action of the Board of Health of New York City in condemning, last September, a small consignment of grapes from northern New York. Some over-zealous individuals, proceeding on the principle that if three times be good, six times would be far better, sprayed their grapes so often as to have them coated with a greenish deposit. These, being unsightly, were naturally condemned, but this condemnation carried with it a wholesale denunciation of all sprayed fruit, which was entirely unreasonable and manifestly absurd. The action, however, seems to have borne fruit in the outcry raised against American fruit in foreign countries, especially in England. To counteract the erroneous idea of the danger of using sprayed fruit, the Department of Agriculture has issued a bulletin§ in which the subject is considered by the chiefs of the two divisions of Entomology and Vegetable Pathology.

The *Entomologist* reports that investigations have long ago been made which show there was absolutely no arsenic in plants where it had been applied to the soil in sufficient quantities to kill the plants themselves. Consequently, the only danger to be apprehended is in the quantity of poison to be found on the fruits of the plants. It is stated that where cabbages are treated with Paris green each head will receive about one-seventh of a grain of the poison, and as half of this will be on the outer leaves or on the ground, it would be necessary for one to eat 28 heads of cabbage before he could receive a poisonous dose! Again, in the case of apples treated for codling moth, as only one pound of poison is used in 200 gallons of water, the amount of poison on each individual apple must be very small, so small, indeed, that it would be necessary to eat several barrels of apples, stems, calyx, skins and all, before enough poison would be taken to have any fatal effect. The individual would probably die from the effect of eating apples long before the poison could take effect.

Spraying for fungous diseases of plants, as shown by the first part of this article, is mainly performed with solutions of copper sulphate and copper carbonate. Whether these are poisonous, whether, in fact, copper is in itself a poison, is still a disputed point. The question was argued for seven months before the Belgium Royal Academy of Medicine. During this period no case of poisoning from the daily use of small quantities of copper for considerable periods was adduced. One result of the discussion, however, seems to have been the repeal of a law prohibiting the regreening of vegetables by means of salts of copper.

It seems quite evident that if, during the five years in which the copper compounds have been used for spraying fruits, any fatal results have occurred, they would have been heard of. As a matter of fact, not a single authenticated case is on record. Furthermore, it has been found from careful analyses of sprayed grapes that the amount of copper in them is not in excess of that in unsprayed grapes; and that one would have to eat from 300 to 500 pounds of the fruit before being poisoned by the copper. The absurdity of the fear becomes even more manifest when we find that in wheat there is more copper than in properly sprayed grapes; while in chocolate there is twenty-five times as much. In the regreened French canned vegetables there are from seven to thirty times as much copper as in grapes. Those not afraid to eat these palatable vegetables need have no fear of sprayed grapes or apples.

* Farmers' Bulletin No. 5, p. 4.

† Report of Commissioner of Agriculture for 1886, 1887, diagram preceding p. 130.

‡ The value for the oats for one year is estimated by dividing the total for ten years by ten. This, therefore, is merely approximate.

§ Farmers' Bulletin No. 7. Spraying fruits for insect pests and fungous diseases, with a special consideration of the subject in its relation to the public health.

WHAT TO PLANT ON THE HOME GROUNDS.

By Prof. J. L. BUDD.

THE station correspondence has many queries in regard to selection of the most desirable shade and ornamental trees, shrubs, and small fruits, for the home grounds.

The appended notes give the result of long trial on the college grounds, supplemented by reports from intelligent amateurs in the north half of the State. At this time the selections are made specially for the parts of the State north of the 42d parallel, yet the few select varieties and species do well in all parts of the State.

SHADE TREES.

Hard Maple (Acer nigrum).

As a combined shade and ornamental tree a well grown hard maple has no superior. Where nursery-grown, root-pruned trees are obtainable, it is a more rapid grower than is usually suspected by those who have planted the cut-back trees from the forest. Trees on the college grounds fifteen years old from the seed are now much larger and handsomer than trees from the forest twelve feet in height planted at the same time.

The value of this tree in grove for sugar making, as grown on the prairies, has so far been overlooked by most planters in Iowa.

Hackberry (Celtis occidentalis).

Though widely distributed in the West, this is a scarce tree in the timber and rarely seen under cultivation, yet in Europe it is a favorite shade tree, and by selection has been run into many varieties, not one of which is more attractive than our native Iowa species.

Bass Wood (Tilia Americana).

In a state of nature this is only found, as a rule, on the low bottoms of our streams and in ravines. But no tree does better on dry upland prairie in isolated positions if nursery-grown. If transplanted from the timber, the stems must be shaded with hay bands until the tops are well established, to prevent sun scalding on the south sides. As yet the linden—as it is called in Europe—is an unappreciated tree for lawn, park, and roadside planting.

White Elm (Ulmus Americana).

This noble tree in isolated positions is also benefited by shading its stem until the top is well established.

Cut-leaved Birch (Betula Amurensis).

That this is a sport of the weeping birch of the Amur valley, in Asia, is now well established. It is proving an ironclad and a thing of beauty on all soils and in all parts of the Northwest so far as heard from. As it is propagated by budding or grafting, it is yet relatively scarce and high priced. Yet all who are anxious to secure beautiful home surroundings can afford one or two specimens of this graceful and striking ornamental and shade tree.

White Pine (Pinus strobus).

In a group, back of the lawn at one side of the residence, the beautiful and graceful white pine shoots up rapidly, and soon forms an attractive retreat for rustic seat and the hammock. As a background group it has no superior.

Red Pine (Pinus resinosa).

This noble tree does well singly, but in home making it is not excelled for grouping to shelter hammock, arbor seats, and the reading chair. It forms a fine contrast with the white pine.

ORNAMENTAL TREES.

Under this heading we include a few desirable trees of small size for lawn and park planting.

Wild Olive (Eleagnus angustifolia).

A small silvery-leaved tree with fragrant flowers. In expression it is something like the buffalo berry, but its leaves are larger; it is handsomer and more fragrant in blossom, the flowers are perfect, and the tree is larger and more graceful in habit.

American Mountain Ash (Sorbus Americana).

Its Northwestern form is a sturdy, round-topped tree of small size, with handsome foliage and clusters of scarlet fruit in autumn. In all respects it is superior to the European species for planting in north Iowa, and indeed in all parts of the State.

Rosmary Willow (Salix rosmarinfolia).

The variety of this from central Russia, as grown from cuttings, is a spreading bush with handsome foliage like that of the rosemary, but when top-worked on the white willow, or *Salix aurea*, it forms a small tree with spreading top and pendulous habit that is very pleasing and peculiar.

White Siberian Almond.

The double white Siberian almond, top-worked on our native plum, forms a small round-topped tree for the lawn with a load of larger handsomer flowers than it bears in bush form. Top-working also increases the hardiness of its wood and fruit buds.

Prunus triloba.

When top-worked on the plum, this is much like the above, except its flowers are larger and pink in color. It succeeds best top-worked on the miner or some one of the Chickasaw varieties.

Amur Choke Cherry (Prunus maacki).

This is the *May day* tree of east Europe. In our climate it is the first small tree to come into full leaf in the spring, and its great racemes of white flowers are always expanded on the first of May. It fruits so freely that it will soon become common in our nurseries.

Weeping Bird Cherry (Prunus padus).

This is a weeping variety of the European bird cherry. It forms the finest small tree when top-worked on seedlings of our native choke cherry.

Tree Lilacs.

Our common red and white lilacs can be grown in tree form by trimming up and keeping down the crown shoots until they begin to blossom freely. When it reaches this stage its crown sprouts give little trouble. The *Amur tree lilac*, however, does not sprout in this way. It forms a neat, small tree with handsome rust-proof foliage and long panicles of pure white flowers. It is now offered quite freely by the Eastern nurseries.

Tree Snowball.

The common snowball can also be grown easily into tree form by slight trimming up and keeping down the crown sprouts until it begins to bloom freely.

Tree Berberry (Berberis Amurensis.)

The Amur berberry also forms a neat round-topped tree of small size with a little care during the first year's growth. In late summer and fall, when loaded with its large scarlet fruit, it is not excelled in beauty.

Russian Privet.

Grown in bush or tree form, this is hardy so far as heard from in north Iowa. At Ames it is rarely beautiful in foliage, and its white racemes of flowers are very fragrant. Its crops of dark purple berries in autumn are also attractive.

Pea Tree (Caragana arborescens).

This small tree, with acacia-like foliage, is desirable at the North for lawn planting. It is pretty in foliage, flower and when loaded with its scarlet pods in autumn. It also makes a fine stock on which to top-work the dwarf species of the caragana with weeping habit. Some small trees grown in this way in north Iowa are as handsome as some of the Australian acacias, so much admired by those visiting California.

Mountain Pine (Pinus pumilio).

This fine dwarf pine is now common with evergreen growers. We have specimens in north Iowa on lawns with a spread of top fifteen feet in diameter and not more than six feet in height at the center of growth. In the near future it will be highly prized.

Silver Spruce (Picea pungens).

The silvery-leaved specimens are not equaled in beauty by any known species. Some of our nurserymen should make a specialty of growing it from cuttings taken from the finest specimens. Yet, as they attain size, all of the seedlings make beautiful trees on lawn or in park.

White Spruce (Picea alba).

This is each year becoming more popular as a lawn tree. Those from the Lake Superior region and the Black Hills are proving more valuable in north Iowa than those grown from seeds from the States east of the lakes.

SHRUBS.

Hydrangea.

The hardy hydrangea, said to be from Japan, but really from northeast Asia, should have a place on every lawn. To reach its highest perfection it should have a mulching of manure, and its new growth should be cut back one-half in the fall.

Tamarix.

The Amur tamarix should have a dry position on the lawn. It will even grow on a dry mound, or on the top of a dirt cave, where only the sedums thrive. This also should be pruned in autumn to preserve graceful form of top and a habit of free and continued flowering.

Rosa rugosa.

The red, white, and half double pink varieties of this east European rose are worthy a place on all lawns at the North. To flower well, and preserve handsome form and foliage, they should also be pruned back in autumn. Other iron-clad roses are Madame Plantier, double white, and the yellow and white Harrison.

Mock Orange.

Several of the largest flowered and most fragrant varieties and species of the Philadelphus do well on varied soils. If confined to two species, perhaps *P. zeyheri* and *P. coronarius* are as desirable as any others for general planting. They also need annual cutting back to preserve symmetry of bush and large and perfect flowering.

Lonicera splendens.

This is a near relative of our common bush honeysuckle, but it is handsomer in outline of bush, has prettier foliage, has more numerous flowers, and a more abundant crop of berries. It runs into varieties with red and yellow berries and varied colored flowers.

Lonicera Alberti.

This is weeping in habit, and when young it trails on the ground. But each year the center is raised, until it becomes a compact pillar with pendent points of growth. It is handsome in flower, fruit and foliage.

Top-worked on a strong stem of Tartarian honeysuckle the *Alberti* forms a round head with branches reaching to the ground.

Lonicera Kylosteum.

Of the bush honeysuckle family, with pendent branches and very large shining red berries. Very desirable.

Climbing Honeysuckle.

Our native climbing honeysuckle (*Lonicera sempervirens*), and its varieties coming back to us from Europe, are vigorous growers with grand foliage and berries. If annually cut back, they become self-supporting and objects of great interest.

Spiraea Van Houtteii.

This is a favorite over the north temperate zone, and we are glad to state that it is perfect in north Iowa. It should be common in every yard.

Spiraea Douglasi.

This was introduced from east Europe, and is not the variety found in Eastern lists. It is very attractive in autumn, when loaded with its large purple panicles.

Snowball.

Of the snowball family the common variety, the *Viburnum lautana*, and the high bush cranberry (*Viburnum opulus*), are all desirable. In north Iowa the latter is valuable as a fruit producer for the making of marmalade.

Virginia Creeper (Ampelopsis quinquefolia).

As a climber for trellises, porches, etc., this has no equal in the temperate zones. Yet it is rarely seen in north Iowa. In autumn, when touched with the first frost, it is gorgeous, and at all seasons it is handsome.

SMALL FRUITS.

The Grape.

In order of ripening the following varieties have given the best returns in the north half of Iowa: Moore's Early, Cottage, Worden, and Concord. On any dry, upland soil, in quality and quantity, these varieties will surprise the novice who has learned to give them the needed culture, pruning, and winter protection. The essentials of culture are best learned by observation in your near vicinity. The only requisite noted at this time is the need of deep setting. Plant on dry ground fully 18 in. deep. Fill up partially at first, and complete the filling when the vine has made some growth. With this deep planting the loss of the upper roots by winter freezing does not affect the lower set of water-feeding roots. It should also be stated that Moore's Early thrives better and bears better crops if pruned longer than is common with the Concord. Some growers urge that the fruit spurs of this variety should have from seven to ten buds.

Strawberry.

The varieties giving the best results as to quantity and quality at this time on varied soils are Warfield, Haverland, and Crescent, all of which are pistillate. The best fertilizers for these are Beder Wood and Parker Earle, adding perhaps for family use, Downer's Prolific.

The following points in strawberry culture are generally conceded:

(1) It is best to set quite late in the spring on fall plowing, as this lessens injury from cut worms. Set in rows 4 ft. apart and the plants about 18 in. apart in the rows, and form matted rows about 18 in. wide, as early in the season as possible, by good culture.

(2) In setting out plants there is no gain in puttering to spread the roots in natural position. Wet the roots, press them together with points downward, and plant very tightly with spade or dibble, as you would a cabbage plant. The roots projected downward answer the purpose until new roots are grown in proper position.

(3) To secure fertilization in weather not wholly favorable it is best to plant alternate rows of the staminate and pistillate varieties.

(4) It does not pay to gather more than two crops from one planting. Have a new plantation coming on and never hesitate to plow up the old one after gathering the second crop.

Raspberries.

Of the black cap family, the Older, Tyler, and Shaffer's Colossal are giving the best crops of best quality for dessert and canning in north Iowa. The secret of setting the tips to secure a uniform stand is to put them in with the roots pressed downward as in planting the strawberry, leaving the crown at the surface or near it. Deep planting always results in a poor stand.

Of the red species the Cuthbert has given the best satisfaction for home use.

At the North it will pay to cover the raspberry as is now practiced with the blackberry. By watching the neighbor who has become an expert, it will be found that the job of covering is not as great a labor as is usually suspected.

Blackberry.

The Snyder and Ancient Briton have the lead. Do not plant unless you decide to cover in winter, which will bring crops that will surprise the novice. The Ancient Briton is fully equal to the Snyder in size, quality, and quantity of fruit, and the canes are smaller, tougher, and easier to cover.

Currant.

The best currant to grow for home use is the White Grape. Its fruit is sweetest and best for dessert use, its jelly has the best flavor, and it is superior to all others in quality for canning.

If a late red berry is wanted, the Victoria is not excelled for Northern culture. The Fay is larger, but it is more sprawling and delicate in habit and the fruit is poorer in quality.

If you want first-class currants in size and quality, set in rows in the open sunshine, cultivate thoroughly, and manure heavily. In pruning, permit the new wood to come on and cut out the wood that is four years old or upward. The Black Naples currant has a value not realized, except by our settlers from England. By scalding the fruit for a few moments in boiling water, and then putting into fresh water for cooking, the peculiar flavor of the skin is removed, and when canned for winter use it is much like the cranberry sauce in flavor and color.

In growing the black currant, it must be kept in mind that it is borne on fruit of the preceding year's growth, and to secure a succession of new wood it is necessary to cut back the points of growth each fall.

The Crandall has no relative value for any use.

Gooseberry.

If set in the open sunshine and treated in all respects as recommended for the currant, the Houghton's Seedling is not excelled in health of bush, productiveness, or quality. This opinion in regard to the quality of the Houghton is shared at this time by Eastern growers, who are able to grow the Downing, Industry and other larger fruited varieties. In quality the Houghton is as much superior for canning to the Industry as the White Grape currant is superior to Long Bunched Holland. Though relatively small, it is firm in texture and by the masses is wholly unappreciated.

Dwarf Juneberry.

We have in the State several varieties of Dwarf Juneberry, originally introduced, without doubt, from the eastern slopes of the Rocky Mountains. All of them produce bountiful crops of really excellent fruit—comparing favorably with the huckleberry—but the birds are so fond of it that where only a few bushes are grown it is difficult to secure a ripe berry unless the bushes are covered. Yet the fruit can be saved, as the mosquito bar can be used several years in succession, if carefully stored when not in use. But recently it has been found that where an acre or more of the Dwarf Juneberry or the cherry is grown, the fruit taken by the birds is hardly missed, probably for the reason that the birds of that season are local in their habits. The best varieties we have tried are the one grown by C. F. Gardner, of Osage—now called "Osage"—the Green County, and two or three others received from Colorado. In reality, none of them is superior to the Osage, which has long been grown in a small way in Mitchell County.

Not Exhaustive.

It scarce needs saying that the above lists are not exhaustive. Under all the headings species and varieties may be added which are the favorites of many. The intention has been to suggest a few things for home adornment and comfort which have been widely tested for a long period on our prairie soils.—*Bulletin Iowa Ag. Exp. Station.*

SYNTHESIS OF TARTARIC ACID.

A NEW and very simple mode of synthesizing tartaric acid has been discovered by M. Genvresse, and is described by him in the current number of the *Comptes Rendus*. It will doubtless be remembered that, some years ago, Dr. Perkin and Mr. Duppa prepared tartaric acid artificially by treating di-brom-succinic acid with hydrated oxide of silver, and this operation became the final stage of a complete synthesis from the elementary constituents, when, a short time afterward, Prof. Maxwell Simpson succeeded in preparing succinic acid by the action of caustic potash upon the di-cyanide of ethylene. M. Genvresse now shows that tartaric acid may be directly synthesized by the action of nascent hydrogen upon glyoxylic acid, CHO—COOH, the curious compound, half aldehyde, half acid, derived from glycol, and hence directly from ethylene. If we double the formula of this acid, and add two atoms of hydrogen, we arrive at tartaric acid, COOH—CHOH—CHOH—COOH, and this is found to be capable of realization by reacting upon glyoxylic acid with nascent hydrogen liberated in its midst by the action of acetic acid upon zinc dust. A mixture of glyoxylic and acetic acids, the latter diluted with an equal weight of water, in the proportion of one molecule of glyoxylic to three molecules of acetic acid, was treated in small quantities at a time with zinc dust, at first at the ordinary temperature, and finally over the water bath. The liquid was then filtered, and the zinc in solution removed by means of potassium carbonate. The clear liquid was then mixed with calcium chloride solution, and after removal of any calcium carbonate precipitate, a white crystalline precipitate commenced to separate. This precipitate was found to yield all the reactions of a tartrate, such as silvering glass when gently warmed with ammonia and silver nitrate. Its analysis gave numbers indicating the formula

$$C_4H_4CaO_6+4H_2O,$$

which is the composition of ordinary tartrate of lime. By treating this salt with the calculated quantity of sulphuric acid diluted with twenty times its volume of water, filtering off the precipitated calcium sulphate and evaporating the filtrate over oil of vitriol, the acid itself was obtained in large crystals. It is interesting to find that the tartaric acid obtained by this mode of synthesis is the optically inactive variety known as racemic acid, there being apparently equal numbers of molecules of both the dextro and lævo varieties produced. The crystals consequently do not show hemihedral faces; the angles observed corresponded with those observed by Provostaye and by Rammelsberg in the case of racemic acid. It may be remarked that, as the product of the synthesis of Dr. Perkin and Mr. Duppa, a mixture of racemic acid with the truly inactive tartaric acid, in which neutralization within the molecules themselves occurs, was obtained. This new synthesis of tartaric acid from glyoxylic acid would appear to throw some light upon the natural formation of tartaric acid. For, remembering the close relationship between glyoxylic and oxalic acids, which latter we know to be one most readily formed in vegetable tissues, and the reducing agencies which appear to be connected with chlorophyl, we have all the means at hand to account, in view of the work of M. Genvresse, for the natural synthesis of tartaric acid.—*Nature.*

THE DOUBLE CYANIDE OF ZINC AND MERCURY.

PROFESSOR DUNSTAN has already shown that when a solution of zinc sulphate is added to a solution of mercuric potassic cyanide, or when mercuric chloride is added to a solution of zincic potassium cyanide, a white precipitate is formed, which does not consist, as stated, of a double cyanide of zinc and mercury of the formula $ZnHg(CN)_4$. Further experiments, an account of which was given by Professor Dunstan at the meeting of the Chemical Society on March 17, indicate that this precipitate is in many respects a remarkable substance. The quantity of mercuric cyanide retained is dependent on the amount of water present during precipitation, as well as on the proportion in which the salts interact; the maximum quantity retained is 38·5 per cent. Zinc cyanide, having this percentage of mercuric cyanide attached to it in such a form that it cannot be removed by ordinary washing with cold water, is precipitated when cold saturated solutions of the two salts are mixed in equimolecular proportions. A series of experiments, in which the masses of the interacting salts were varied, proved that a compound of the two cyanides is formed, and suffers decomposition to a greater or less extent, depending on the relative amount of water present. Examination led subsequently to the inference that the composition of the double salt is expressed by the formula $Zn_4Hg(CN)_{10}$. Such a salt contains 40·6 per cent. of mercuric cyanide. It cannot be obtained pure, since it is decomposed by water, and it can only be produced by precipitation of aqueous solutions. All attempts to prepare the double cyanide by methods other than that of precipitation have failed. There was no forthcoming evidence of the existence of any other compound of the two cyanides than that described, nor could any similar compound of zinc cyanide with other metallic cyanides than that of mercury be obtained. It is widely known now that this tetra zincic monomercuridecacyanide has been found to be an admirable surgical antiseptic. Sir Joseph Lister, its introducer, who was present at the meeting, and at whose suggestion the inquiry was undertaken, said that the great value of the salt arose from the circumstance that, while equally effective as an antiseptic, it had none of the irritant qualities of mercuric cyanide, and its slight solubility was an advantage. When mercuric chloride was used it was liable, on the one hand, to be washed away by the discharges of a wound, and, on the other, to accumulate until a solution was formed which was so concentrated that it caused great irritation. He was glad that Professor Dunstan had come to the conclusion that it is a definite chemical compound, because he had not been satisfied from its behavior that it could be a simple mixture.—*Lancet.*

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Scientific American Supplement.

PUBLISHED WEEKLY.

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